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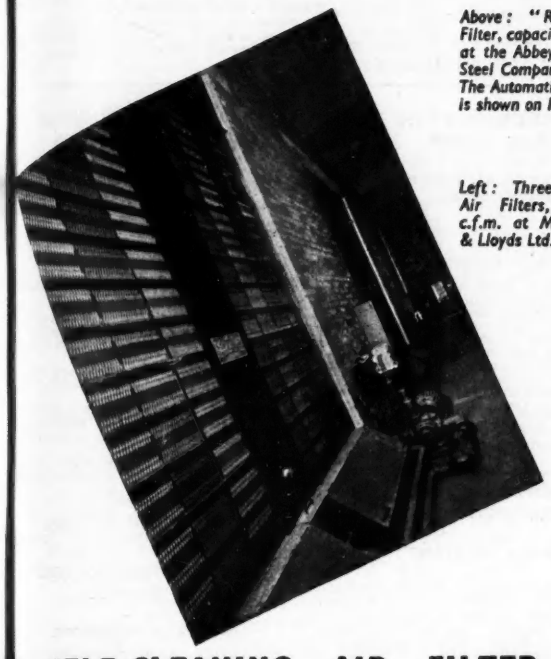

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THE ENGINEER

ESTABLISHED 1856

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E. R.

By Order of the Minister of Supply

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		Main Location	*Auctioneers*
December 10–11	Machine tools and miscellaneous stores, lincuding large quantity of clothing	M.O.S. Storage Depot, Ruddington, Notts	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
December 16	Approx. 150 vehicles, including cranes and platform truck	61 "B" Vehicle Depot, R.A.O.C., Georgetown, Paisley, Renfrew. (Sale at Cattle Market, Graham Square, Glasgow, E.1.)	DIXON & WALLACE (Dept. L), Bank Buildings, Graham Square, Glasgow, E.1. Tel.: Bridgeton 2447.)
December 18–20	Machine tools and miscellaneous stores, including radio and electrical test equipment	Technical Stores Depot, Old Dalby, Melton Mowbray, Leics. (Sale at Melton Mowbray.)	SHOULER & SON (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 81.)
December 18	Miscellaneous stores, including :—	Command Ordnance Depot, Kinnegar, Co. Down, Northern Ireland. (Sale at Belfast.)	OSBORNE KING & MEGRAN (Dept. L), 14, Montgomery Street, Belfast, N.I. (Tel.: 30433.)

Women's clothing, including greatcoats, cooks' and combination overalls, jerseys, skirts, gloves and slacks, women's boots and shoes, linen bags, shirts, M/T spares, etc.

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THE ENGINEER

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THE CANADIANS

Last week we had the opportunity to meet a few members of the Canadian Trade Mission which is now visiting this country when a party of them visited Garringtons, Ltd., at Bromsgrove. There are fifty-seven people in the mission and each day several small parties are arranged to visit different firms within the particular area which the Mission is visiting. Relatively few members of the Mission are technical engineers, though a large proportion are presidents or vice-presidents of engineering companies or of companies largely using the products of engineers. The purpose of the Mission is not so much to study how engineering and other products are made in this country as to discover what is made here and what products could profitably be imported into Canada.

There is no question in our minds, having met some of these Canadians, that they are already deeply impressed by what they have seen, although their journeying has but well begun. One member of the party, better informed than the rest because he had recently visited this country, remarked with a chuckle that the visit was proving " a bit of an eye-opener " to many of his companions. Very few Canadians are quite so " insular " as Americans from the Mid-West, most of whom seem barely conscious that any country outside the States is capable of making anything at all. To the people of the Mid-West it was no doubt a peculiarly shocking discovery that the Russians could girdle the earth with a couple of satellites before they could! But even so, quite a few members of the Canadian Mission obviously came over to Britain with the idea that the people here were a bit decadent, even if not a little senile, and certainly less vigorous than Canadians or Americans. They think so no longer. To judge by those with whom we talked they have even given up complaining that it was no use in the post-war years attempting to place orders in Britain because delivery dates were too far ahead and supplies of spares uncertain. They did not appreciate, the general opinion seems to be, to what an extent we had to rebuild our industries nor with what great energy we are doing so. The Canadians are, too, impressed by the abundant evidence of a concern to increase output and raise productivity. Commercially the point is of importance. For though the demand of the Canadian market is very substantially smaller than that of the U.S. market it can still be about as high as that of the British home market for similar goods. Thus, if some product imported from Britain " catches on " the Canadian importer likes to feel confident that expanding output here will be capable of meeting expanding demand over there. But most of all, perhaps because of a preconceived idea that they would not find it so, the Canadians appear impressed not only by the vigour with which industrial expansion is being pursued in this country, but also by the technical competence and even brilliance being displayed. They had not expected to find Britain leading the world in design in some industries or leading the way in layout for high productivity in others, whilst preserving in the product the customary reliability and longevity. As one of them remarked to us " When we get back to Canada we shall have a wonderful tale to tell."

The likelihood that very many orders will actually be placed by the Mission is probably rather low. Its members are on a voyage of discovery rather than a purchasing mission. They wish to discover whether it would be possible to switch some of Canada's purchases from the United States, with which Canada runs a trade deficit running annually at well over 1000 million dollars, to this country with which it runs an annual surplus of some 300 million dollars. The recently elected Prime Minister of Canada, Mr. Diefenbaker, hopes that 15 per cent of the purchases at present made in the U.S. can be switched to Britain and the Commonwealth. Our impression is that the Canadian Trade Mission will return to Canada convinced that there would be nothing impossible, nor even very difficult about the making of such a change. Furthermore the interest shown up and down this country in the Mission, which has been inundated with invitations from firms hoping to entertain parties, proves that industrialists here are alive to the opportunity of breaking into the Canadian market. Both Canada and Britain would benefit.

A MACHINE TOOL DEVELOPMENT PROJECT

The basic design of the individual part or small batch production machine tool has changed but little for many years. Refinements have been added to facilitate operation, increase precision and raise output, but the form of the lathe and of milling, grinding, drilling and other machines remains generally the same. A note, which we reproduce on another page, recently presented to the Machine Tool Advisory Council, says that very few such machines approach in operation the overall speeds of which they are generally capable. It stresses that a major limiting factor in applying control systems to improve accuracy and output is the mechanical design of the machine tools themselves. It is, of course, appreciated that the limiting factors in the basic design of orthodox machine tools do not apply to special purpose high production and certain high precision machines. The limitations imposed by machine tool design have led the National Research Development Corporation to institute a general investigation into the mechanical elements which go to make up a machine tool. These investigations will be made at the Manchester College of Technology and the entire cost of the project will be borne by the Corporation.

This project will immediately remind many visitors to recent machine tool exhibitions of the way in which a number of orthodox machines are being fitted with ancilliary and auxiliary equipment to speed production and increase accuracy. That most of these additions adequately serve their purpose there is no doubt; but although they are often useful for a certain range of work they not infrequently provide an obstruction when a machine is required for a range of individual jobs of widely different dimensions and forms, such as are met with in a general shop. A stage has now been reached where ancilliary equipment can cost appreciably more than the basic machine, and potential purchasers—particularly those with small shops—find it difficult to justify the initial capital cost of such equipment. Perhaps redesign of the basic elements will enable this problem of economics to be overcome—for it must be remembered that, generally speaking, the biggest producers of individual components are the smaller shops in the engineering industry.

There is no doubt that the investigation will appeal to all machine tool users as a project which holds great promise, and the results will be awaited with great interest. Perhaps the project will lead to a radically new conception of a number of orthodox machine tools which will incorporate quick and easy control with speed and accuracy, and which will be available at an economic price to all users. To develop such machines a completely new approach to design can best be made in an establishment where there exists no bias towards orthodox practice or limiting commercial considerations. The Manchester College of Science and Technology has these advantages combined with the facilities of well-equipped design, metrology, electronics and other departments which should be of considerable advantage in carrying out the projected work.

F.B.I. OVERSEAS SCHOLARS

On several occasions in recent years we have made reference in these columns to the Overseas Scholarships Scheme, which was initiated in 1950 by the Federation of British Industries. It is a pleasure to return to the subject, for, last Friday, there was welcomed, at a reception in London, the 200th engineer from overseas to visit this country under the scholarships scheme. He has come from Australia.

It is not amiss to recall the details of the F.B.I. scholarships scheme. It is a scheme which provides practical training with engineering firms in this country for graduate engineers from developing countries overseas. The scholars are chosen very carefully by local selection committees, and during the time they spend in this country they have every opportunity to become familiar with British engineering practice, methods and equipment. What is equally important is that they are able to see at first hand the British way of life. The 200 scholars who have so far been received under the scheme have been drawn from twenty-five countries in the Commonwealth, Latin America and the Middle East. Of the total, 106 scholars have completed their training and returned home, leaving ninety-four still in this country. At present, 150 new scholarships are on offer in the same twenty-five countries as well as in five additional countries and the British Colonies. The cost of the scheme is met partly by contributions from those engineering firms which provide the training facilities and partly by a Government grant, the F.B.I. taking responsibility for administering the scheme and for the welfare of the scholars while they are here. It is interesting to learn that recently a supplementary scheme has been introduced jointly by the Federation of British Industries and the British Council. The function of this is to provide in this country combined courses of practical training and post-graduate academic studies for full-time or part-time professors or lecturers in engineering subjects in overseas institutions of university rank. This " supplementary " can undoubtedly be most valuable to the continuing success of the F.B.I. Scholarships Scheme, for overseas professors and lecturers who participate in these courses will be ready, it is hoped, as a result of their experience in Britain, to influence future students to apply for scholarships.

At the reception to the " 200th arrival " last week, there was opportunity to talk with some of the overseas scholars who were present. It was encouraging to do so, for there is no doubt that they value highly the engineering experience which they are gaining in this country, and there is no doubt that they value just as highly their experience of the " British way of life." Those are but two aspects of the F.B.I. scholarships scheme which cannot fail to be beneficial to this country. The value of the scheme is now being further enhanced by the growth of the F.B.I. Scholars' Association which already has branches in three overseas countries. One of the aims set out in this Association's constitution is " to promote mutual knowledge and understanding between the scholar's home country and Britain." At present, the association is but an infant, albeit a lusty one ! We shall watch its development with interest, for, we believe, there opens out before it a most promising future. In science and technology, international barriers have no place. The F.B.I. Overseas Scholarships Scheme and the Association which has grown out of it demonstrate that very ably. May their endeavours continue to be successful.

The Engineer

100 Years Ago

(DECEMBER 4, 1857)

" SMOKE ABATEMENT "

" There are few things about which certain persons think themselves so wise, but about which they are really so ignorant, as what is called ' the consumption of smoke.' Everyone believes he knows what he means, and what is meant by others, when the expression is used, and consequently few can appreciate the distress of some scientific persons when they hear of smoke being ' consumed.'

" It is the more necessary that we should at this time draw attention to the subject, inasmuch as the amendment to the Smoke Nuisance Abatement Act comes into operation on the first of next month, and will, doubtless, considerably enlarge the field for the profitable employment of any really useful inventions for smoke prevention. By this amendment not only is the exemption removed which was granted to glass and pottery works, but all vessels plying in the Thames above the Nore will be compelled to adopt some means for preventing the emission of dense volumes of smoke from their furnaces. There can now be no doubt that Parliamentary interference, as regards the abatement of the smoke nuisance has operated most beneficially ; and notwithstanding there have been many hard cases of small tradesmen, such as bakers, being compelled to incur considerable expense in the alteration of their ovens, and not always even then avoiding being heavily fined, yet upon the whole the manufacturing community have suffered but very little from being obliged to conform to the regulations of the Act. In many cases there can be no doubt that the saving effected in the consumption of coal has many times covered the amount expended in making the necessary alterations in the furnaces ; and we have no doubt that the convictions would be far less numerous than they now are were the public better informed on the subject of smoke prevention."

A Seven Day Journal

Nuclear Propulsion of Ships

In last week's issue we printed a paper on "Nuclear Propulsion of Ships," by Sir Christopher Hinton and R. V. Moore. We said the paper was presented before the Institution of Naval Architects. That was an error. The meeting was organised by the Joint Nuclear Marine Propulsion Panel, to which our apologies are due.

The Joint Nuclear Marine Propulsion Panel was set up in 1955. The reason for its inception was that the British Nuclear Energy Conference, which at that time had just been announced, did not seem to be constituted in such a way as to give adequate facilities for the discussion of the problems associated with the nuclear propulsion of ships. As it had been expressed authoritatively and publicly that there would possibly be greater development of nuclear plant for marine use than in any other field, it was felt by the Council of the Institute of Marine Engineers that something should be done to provide facilities for the discussion of the marine application comparable with the importance of the subject. The Council of that Institute therefore decided to set up an organisation for this purpose and invited the Institution of Naval Architects, the North East Coast Institution of Engineers and Shipbuilders, and the Institution of Engineers and Shipbuilders in Scotland to co-operate. This resulted in the formation of a panel set up under the style of "The Joint Nuclear Marine Propulsion Panel." The Institute of Marine Engineers is represented on the panel by Vice-Admiral Sir Frank T. Mason, K.C.B. (chairman); Rear-Admiral F. E. Clemitson, C.B.; Mr. R. Cook, M.Sc.; Mr. H. N. Pemberton, and Mr. H. N. E. Whiteside. The Institution of Naval Architects is represented by Mr. J. M. Murray, and Sir Victor Shepheard, K.C.B., R.C.N.C. The North East Coast Institution of Engineers and Shipbuilders is represented by Dr. T. W. F. Brown, and Professor L. C. Burrill, M.Sc. The Institution of Engineers and Shipbuilders in Scotland is represented by Mr. G. Johnson, and Mr. P. W. Thomas.

The secretary to the panel is Mr. J. Stuart Robinson (secretary, the Institute of Marine Engineers).

Proposals are afoot at the moment for the possible reading of approximately one paper per session in each institution, the reports of which and the discussions thereon are published separately and additional to the journals of the institutions. This *Journal of the Joint Panel on Nuclear Marine Propulsion*, which is published twice a year, is issued free to members of the four institutions and is available for purchase by non-members.

Mining Research

The Royal School of Mines of the Imperial College of Science and Technology has issued its Research Report for 1954–57; since the first triennial report was issued, new Chairs have been established in Applied Geophysics and Physical Metallurgy. Research in extraction metallurgy includes the development of techniques for equilibrium studies of pyrometallurgical systems at temperatures up to 2000 deg. or 3000 deg. Cent. Work on physical metallurgy has embraced precipitation hardening, work on three ternary systems having been completed and on two quaternary systems commenced, and failure of high-tensile brasses (manganese bronzes) by cracking and creep—a dispersion that resists both intercrystalline cracking and creep has been evolved.

The Department of Mining Geology has been responsible for the establishment of a Geochemical Prospecting Research Centre to aid mineral exploration, particularly in British Colonial territories. Field work in many parts of Africa has been so successful as to lead mining companies to an increasing use of geochemical methods. The Department of Applied Geophysics has utilised a variety of the techniques at present known, having carried out gravity meter observations in the Scottish Highlands and in the Azores, and developed a new type of magnetometer based on nuclear magnetic properties (the polarisation of protons in the nuclei of certain liquids in a magnetic field), which gives absolute readings with great speed, at a cost of complicated electronic equipment, provided disturbances such as electric railways are not near. An electromechanical shock generator, with a frequency tunable between 100 and 1000 c/s, and a duration of 0·01 seconds, has been developed for seismic prospecting, and an induced polarisation method for locating conductive ore bodies has given promising results.

Water Supply and Effluent Disposal in Western Germany

A delegation from the Federation of British Industries recently visited Western Germany to study industrial water supplies and the treatment of trade effluents. Its report, which is entitled "Trade Effluents and Water Supplies in Western Germany," has just been published. Visits were made to lignite mines and chemical and steel works, and to various installations of river associations and water authorities in the heavily industrialised area surrounding the Ruhr, Emscher, and Lippe rivers.

The report comments that in many ways the basic problems encountered have no parallel in this country; nevertheless, much useful technical information was obtained and the delegation was particularly impressed with the achievements of river and water associations in meeting the requirements of rapidly expanding industry. Water is considered as a valuable raw material as well as a vehicle for production, the report continues, and comprehensive schemes for water conservation, land drainage and effluent purification have been devised and paid for on a joint basis. Industry's contribution has been some 30 per cent of the small cost in the Emscher River area, where it is planned to spend £5,000,000 in the next seven years on effluent treatment plants alone.

Iron and steel works showed some impressive examples of recirculation and re-use of water, aimed at economy in usage and in effluent disposal. At chemical works, difficult effluents had been segregated for treatment near the source, and some waste chemicals recovered and used. In the opencast lignite mines, vast quantities of drainage water were disposed of.

The delegation pointed out that in its view problems of water conservation were no less urgent in this country, and their solution, which was vital, could only be achieved along similar lines of co-operation and with considerable capital expenditure.

Kingsferry Lifting Bridge

Work is to start this month on the construction of a new lifting bridge to improve road and rail communication between the Isle of Sheppey and the Kent mainland. It is to be built by the Kent County Council. The estimated cost, including approach roads, is £1,170,000.

The new bridge will be built alongside the existing one over the River Swale at Kingsferry; its vertical lifting span will give a clear opening 90ft wide for shipping. There will be three approach spans on each side of the central lifting span, all seven spans being plate girders. The lifting span will be 120ft long and will give a vertical clearance of 95ft at high water. The total length of the seven-span steel structure will be 650ft, and the total length of the bridge, including its approach embankments, will be 2500ft. The overall width will be more than 50ft and it will carry a 24ft roadway, a 6ft footpath and the railway track. The new approach roads, including a new bridge to carry the road over the railway, will be nearly 3 miles long. The whole scheme is expected to be completed in less than three years.

The existing bridge over the Swale carries both road and railway and is the only land access to the Isle of Sheppey. It has a lifting span of 58ft, and in recent years there have been a number of cases of ships fouling the bridge and cutting off the island from the mainland. The bridge is 25ft wide and carries a single-line railway and a roadway which, at the lifting span, is only 11ft 3in wide. The bridge was built in 1856 as a toll bridge under powers obtained by the Sittingbourne and Sheerness Railway. It was freed from tolls in 1929.

The consulting engineers for the new bridge are Messrs. Mott, Hay and Anderson; the main contractor is John Howard and Co., Ltd. The approach roads will be built by direct labour under the direction of the county surveyor of Kent, Mr. E. W. H. Vallis.

Whitworth Foundation Awards

The Ministry of Education has announced details of the Whitworth Foundation Awards for engineers to be offered for competition in 1958. These awards include Whitworth Fellowships, not exceeding three in number, normally tenable for two years, valued at £500 a year and possibly supplemented by dependents' allowances and allowances for travelling; and up to six prizes of £50 each to unsuccessful competitors whose work deserves recognition, to be spent on furthering the competitors' engineering education. Candidates must be British, and either have an engineering qualification of university degree standard, or have a Higher National Diploma or Higher National Certificate in Engineering with at least two distinctions. In exceptional circumstances a candidate may be in the final year of study leading to one of these qualifications. Each candidate must also have had practical training in engineering totalling 104 weeks. Candidates will be required to write a thesis of from 2000 to 4000 words on a subject approved by the Ministry, and may be required to sit a short examination on the basic principles of engineering and to appear for an interview before an examining body.

Notes on the Use of Resistance Strain Gauges

By P. H. R. LANE, B.Sc. (Eng.), A.I.M., A.M.Inst.W.

During the past eight or nine years the laboratories of the British Welding Research Association have used some thousands of wire resistance strain gauges under varied and often onerous conditions. This article describes some of the techniques which have been proved to be successful, with special reference to the use of gauges under water pressure.

ALTHOUGH the manufacture and use of wire resistance strain gauges has been discussed in many papers since the first extensive use was made of them in 1940, it may perhaps be useful to describe some of their general features.

In essence, resistance strain gauges consist of lengths of fine resistance wire (normally 0·001in diameter) formed into a grid and attached to a thin paper base. Two general forms of construction are used ; the first of these provides a grid in one plane, formed simply by looping the resistance wire over a suitable jig and then cementing it to the backing paper. The form of this grid is then generally as shown in Fig. 1(*a*). The second method consists of wrapping the resistance wire in a helix around a paper former and then flattening this and cementing to the backing paper. The form of the grid in this case is generally as shown in Fig. 1(*b*), and the individual wires are in two planes separated by the paper former. Generally this is of no importance from a practical point of view, but it has occasionally been found to be a slight disadvantage when using gauges under hydrostatic pressure. After the grid has been formed and attached to the backing paper, it is generally covered either with another thin sheet of paper or with a piece of felt. The description above refers only to the simplest straight gauges used for measuring the strain in one direction. Many designs of composite gauges are also available. They consist essentially of several similar elements mounted on a common backing paper.

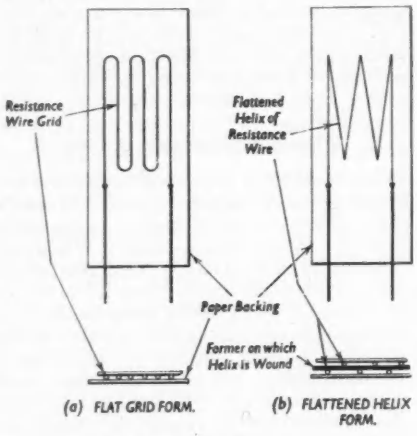

Resistance Wire Grid
Flattened Helix of Resistance Wire
Paper Backing
Former on which Helix is Wound
(a) FLAT GRID FORM.
(b) FLATTENED HELIX FORM.

Fig. 1—Two common forms of wire resistance strain gauge

The technique of attaching strain gauges is described very fully and adequately by their manufacturers, and the method recommended by the manufacturer for any particular gauge will in general be found to give the best results. In the author's laboratory a cellulose acetate adhesive is most frequently used ; the gauges are allowed to dry at room temperature for not less than four or five hours, at the end of which time the majority of the solvent in the adhesive has evaporated. Drying is then completed by gentle heating, which is conveniently applied by commercial infra-red lamps. A simple and adaptable clamping device for holding these lamps in position consists of a short length of heavy electric cable (19/0·083) with lugs soldered to its ends. One of these lugs is attached to a suitable clamp (a powerful magnet is useful when the specimen is steel) and the other carries a spring clip which grips the lamp. This device is illustrated in Fig. 2.

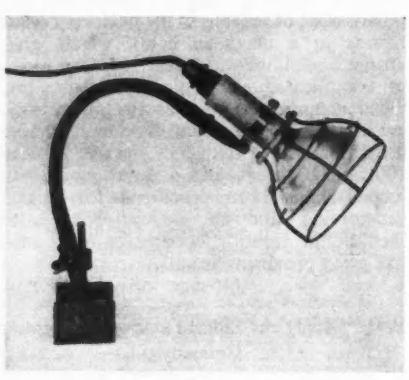


Fig. 2—The base of the stand for the drying lamp shown here is a strong permanent magnet

The usual method of determining when the adhesive is completely dried is to measure the insulation resistance between the strain gauge element and the metal specimen. The standard minimum value used in the author's laboratory is 40 megohms ; generally, however, a value of 100 megohms is attained. It is advisable to use relatively low voltage equipment for checking the insulation resistance, since, if drying is not completed when the test is carried out, the 250V or 500V developed by the conventional insulation tester is sufficient to break down the paper backing of the gauge so as to render it useless. Commercial instruments are available which use voltages of 60V or less.

Where it is necessary for gauges to function satisfactorily for measurements spread over any period longer than an hour or two they must be protected ; the method depending on the conditions of service. For gauges subjected to nothing more onerous than normal atmospheric conditions, a coating of wax is adequate. By the use of a rather harder wax than that often recommended, the gauges are afforded some degree of mechanical protection, in addition to being protected against the absorption of moisture which would lead to a lowered insulation resistance. One wax which has been used with great success has a melting point of 62 deg. Cent., a power factor at 80 deg. Cent. of 0·0005, and a specific conductivity at 85 deg. Cent. of 0·12 micromicro mhos. Another similar wax from the same manufacturer has similar properties with the exception of the melting point, which is approximately 75 deg. Cent. Both are hard enough to withstand normal wear and tear in or out of the laboratory.

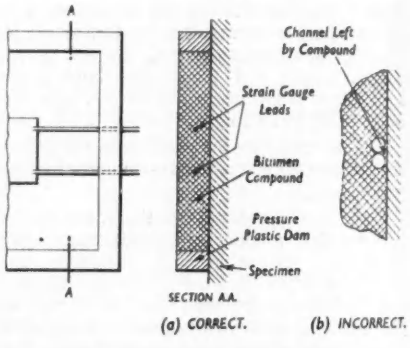
Many tests have been carried out where gauges have been subjected to considerable water pressures (up to 10,000 lb per square inch). For this purpose, wax alone is not adequate and a different technique is necessary. One such technique was described by Tannahill[23] in 1949.* This consisted of the successive application of several layers of water-proofing materials and, whilst it was found to be perfectly adequate, it relied considerably on the care with which the work was carried out. It was, furthermore, a time-consuming and tedious procedure, and so a simpler, but equally effective, method was sought. Tests were initially made with synthetic casting resins. These could be used effectively, but were finally abandoned, partly because extreme cleanliness was essential to their successful use, and partly because of the rather brittle nature of the final casting. Both these properties are undesirable when the work is to be carried out on engineering specimens.

The current method in the author's laboratory uses a commercially available bitumen compound which can be melted and poured over the gauges. The procedure is first to build a dam about ¼in high around the area which has been gauged. The metal within this dam (which will usually have been dressed down to 000 grade emery for the attachment of the gauges) is carefully cleaned with acetone and, where possible, warmed to a temperature of 60 deg. Cent. to 70 deg. Cent. The compound, which is an electrical joint box compound, is then poured in. The material has the following physical characteristics :

Specific gravity	1·02–1·04
Softening point (ball and ring)	70 deg. to 76 deg. Cent.
Pouring temperature	150 deg. to 158 deg. Cent.
Contraction (150 deg. to 20 deg. Cent.)	6·2 per cent
Flash point	Over 260 deg. Cent.
Ductility at 25 deg. Cent. (Specification IP32/55)	4 cm.

Whilst it does not actually contain rubber, the material has a rubbery texture, only

* THE ENGINEER, June, 1949, Vol. 187, page 630.



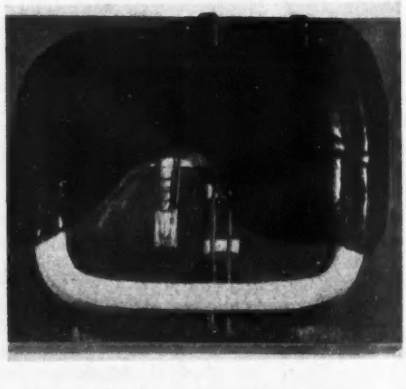


Fig. 3.—Details of waterproofing strain gauges

becoming brittle at very low temperatures.

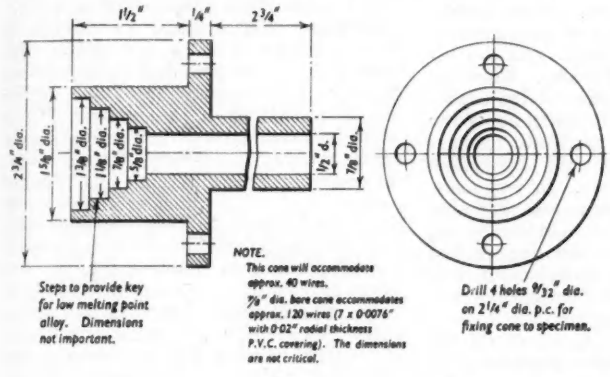
When the compound has cooled it is covered with a layer of shellac-based jointing varnish which can be brushed on. This coating is taken continuously down on to the specimen, outside the bitumen covered area.

Care is necessary where the strain gauge leads are taken out of the waterproofed area. The leads must be supported clear of the specimen in such a way that the waterproofing compound can flow completely around them (see Fig. 3*a*). If this is not done, a small channel remains which permits the entry of water (see Fig. 3*b*). Fig 3 also shows a cutaway view of a pair of waterproofed gauges.

The gauge leads normally consist of 7/0·0076 stranded tinned copper wires insulated with P.V.C. to a radial thickness of 0·020in. As a precautionary measure lengths of wire are pressure tested before use to ensure that the insulation is continuous. For passing the leads out of the vessel, use is made of a steel cone, which is attached to the specimen at some convenient point, with the wide end of the cone towards the pressure. The wires are cleaned, passed through the cone and roughly spread out. The small end of the cone is sealed with a suitable plastic material, and the cone is then filled with a low melting point alloy which has the following properties :—

Melting point	70 deg. Cent.
Tensile strength	2 to 3 tons per square inch
Expansion	0·0051in per inch after 24 hours

The alloy contains bismuth which is responsible for the expansion quoted. This is essential. In order to protect the leads from the sharp edges of the cone the latter are covered with a suitable pressure plastic or tape To ensure the success of this procedure, it is important that the cone should not be disturbed after the alloy has been poured into it, until this has completely solidified (usually about ten minutes). Properly carried, the device has been successful up to a pressure of 10,000 lb per square inch.


1½"
¼"
2¾"
2¾" dia.
1⅝" dia.
1⅜" dia.
⅞" dia.
⅝" dia.
½" d.
⅞" dia.
Steps to provide key for low melting point alloy. Dimensions not important.
NOTE.
This cone will accommodate approx. 40 wires.
⅞" dia. bore cone accommodates approx. 120 wires (7 x 0·0076" with 0·02" radial thickness P.V.C. covering). The dimensions are not critical.
Drill 4 holes 9/32" dia. on 2¼" dia. p.c. for fixing cone to specimen.

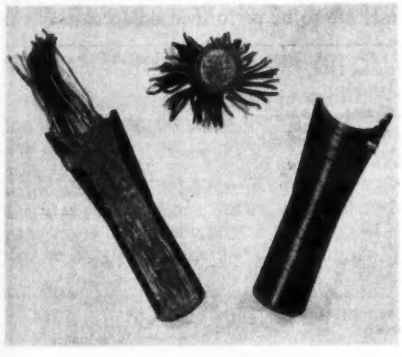
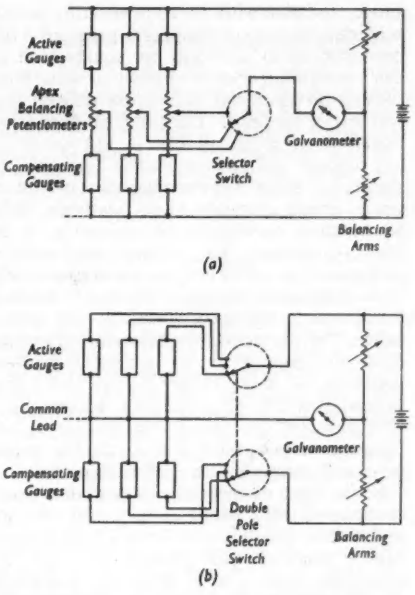


Fig. 4—Steel for strain gauge leads

Fig. 4 shows typical dimensions of a cone and photographs of longitudinal and transverse sections after filling.

A wide variety of measuring instruments for use with wire resistance strain gauges is now available commercially. The selection is usually a matter of personal preference, but for many applications attention should be paid to the rapidity with which readings can be taken. This is not merely in order to save time, but to minimise the effects of zero drift, from whatever cause this may arise. For static strain measurement the author has made extensive use of an American single-channel strain indicator adapted for use as a multi-channel instrument. Most strain indicators are essentially Wheatstone bridges, and it is frequently asserted that, for multi-channel working, switchgear should be located in the galvanometer arm of the bridge, in which position changes of contact resistance will have no effect on the accuracy of the bridge. This arrangement requires a circuit generally similar to that shown in Fig. 5 (*a*), and an apex potentiometer for each gauge is necessary. An alternative circuit is that shown in Fig. 5 (*b*). It will be seen here that the switches are in the resistance arms of the bridge and that therefore any change in contact resistance during the progress of a test would give rise to error in the strain measurements. However, wafer switches with silver-plated clips and silver alloy rotors can be obtained with sufficiently constant contact resistance to give rise to no errors greater than that equivalent to a strain of 5×10^{-6}. With the arrangement shown in Fig. 5 (*b*), the procedure is to take readings on the strain indicator for each gauge when the test specimen is subjected to no load, and then to repeat these readings with successive increments of load. The strain due to the load is then the difference between successive readings of the indicator for that particular gauge. A standard form (shown in Fig. 6) is used for recording the readings. It has been found best to use a team of three operators. One of these operates the selector switches, one operates the strain indicator, and the third records the readings on the standard sheet. With this arrangement it is possible to make approximately 600 readings per hour—that is, with 100 gauge points it would be possible to measure the strain at six increments of load in an hour, excluding the time required for applying the load.



(*a*) With apex potentiometers—resistance of selector switches unimportant.
(*b*) Preferred method without apex potentiometers—high grade selector switches required.

Fig. 5—Alternative methods of multi-channel strain gauge working

On the form shown in Fig. 6, the figure to be entered in the column headed "increment," is the difference between the reading of the strain indicator for the appropriate load and the reading for the preceding load. The figure entered in the column headed "total increment" is the sum of all the increments up to and including the load under which the figure appears. It has been found useful to have both these figures readily available. When the specimen and loading are such that equal increments of load would be expected to result in equal increments of strain, the figures in successive "increment" columns should be sensibly constant. They thus provide an immediate check on the progress of the test. The figures in the "total increment" column are necessary for calculating the stress at any particular load.

It is normal practice to use a compensating gauge which is subjected as nearly as possible to the same conditions as the active gauge with the exception of the applied strain. For the case of gauges subjected to pressure, readings of active gauges have been taken in conjunction with compensating gauges subjected to the same pressure as the active

Record of Strain Gauge Readings

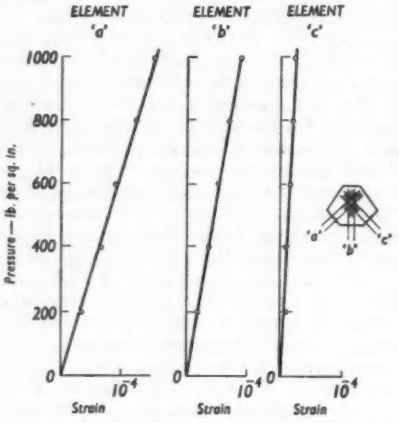
Experiment No.	Specimen	Page No.	Run No.
			Date

Pressure/Load														
Gauge No.	Switch No.	Gauge Factor	Reading	Increment	Total Increment	Reading	Increment	Total Increment	Reading	Increment	Total Increment	Reading	Increment	Total Increment

Fig. 6—Standard form for recording gauge readings

gauge, and also with the compensating gauge subjected only to atmospheric pressure. At pressures up to 10,000 lb per square inch it has been found over a number of tests that there is no significant difference between the two sets of readings. For practical purposes, therefore, it seems that it is not essential to subject the compensating gauges to pressure. Since all the materials used for strain gauge elements have relatively high temperature coefficients of resistance, it is always necessary to provide temperature compensation. This is again usually provided by a compensating gauge subjected to similar conditions to that experienced by the active gauge. While direct pressure compensation does not appear to be necessary (up to pressures of 10,000 lb per square inch) the easiest method of obtaining temperature compensation for gauges on the inside of pressure vessels is often to place the compensating gauges inside the test specimen.

Since much of the author's work has been carried out with strain gauges subjected to hydrostatic pressures of up to 1000 lb per square inch, it was thought desirable to determine what, if any, effect was produced on the strain gauge directly by the pressure. A simple test was made with a rectangular rosette strain gauge fixed to a pipe of 12in bore by 1⅛in thick (nominal) subjected to internal pressure. The strains obtained for each of the three elements are plotted against the applied pressures in Fig. 7. The table



STRAIN/PRESSURE CURVES FOR RECTANGULAR ROSETTE UNDER INTERNAL PRESSURE.

Gauge	Principal Stresses		Angle
	Max.	Min.	
1	1·9	0·7	+7½°
2	2·1	0·8	−2¼°
Calculated	1·9	0·9	0

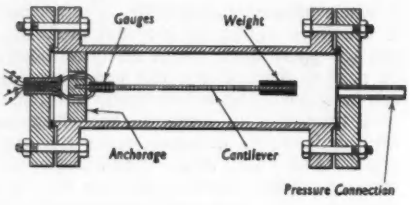
STRESSES IN TONS/SQ. IN. FOR 1000 LB./SQ. IN. PRESSURE IN 12 IN. BORE x 1⅛ IN. THICK (NOMINAL) TUBE.

Fig. 7—Rosette gauge readings under pressure

in this figure shows the stresses determined from two separate rosette gauges, and the values calculated from the usual elasticity expressions. It will be seen that the agreement between the measured and calculated stresses is good and that the direction of the principal stresses is also forecast with fair accuracy.

Tests have also been carried out to determine whether the gauge factor is affected by pressure. For these tests gauges were attached to a small cantilever which could be inserted in a high-pressure pipe, as shown in Fig. 8.

The end of the cantilever was weighted, so that when the pipe was rotated the cantilever deflected through a small arc. The deflection was limited to a constant value by the weight touching the pipe wall. The values of strain due to the deflection of the cantilever at various pressures are shown in the table in Fig. 8. It can be seen that, up to a pressure



Pressure lb. per sq. in.	0	1200	2300	3350	5500	8700	9750
Strain x 10^{-6}	410	420	412	415	403	395	440

Fig. 8—Cantilever for checking effect of pressure on gauge factor

of about 9000 lb per square inch, the strain is virtually constant, indicating that there is no effect of pressure on the gauge factor.

Mention was made above of the application of load in several increments. It is emphasised that the overall accuracy of the measurements can be readily confirmed, and usually improved, by loading in this way. Where the loading is under the control of the experimenter, and is such that it can be applied in increments, four or five successive readings of the strain gauges can be taken and a graph made of load against strain. In very many cases physical considerations will show that such a graph should be a straight line passing through the origin, and by drawing the best straight line through the plotted points it is possible to obtain an accuracy greater than that of any individual reading.

In nearly all engineering structures the stress field on the available surfaces will be bi-axial, and it is then necessary to use more than one strain measurement in order to determine the stresses. When the stresses in particular directions are required, or where the principal stresses on axes of symmetry are to be measured, two perpendicular measurements suffice. Where it is desired to determine the principal stresses and their direction is unknown, at least three measurements are necessary.

When two measurements of strain are taken they are combined according to the usual expressions for a bi-axial stress field, namely,

$$\sigma_x = \frac{E}{1-\mu^2}(\varepsilon_x + \mu\varepsilon_y)$$

$$\sigma_y = \frac{E}{1-\mu^2}(\varepsilon_y + \mu\varepsilon_x)$$

when

σ_x, σ_y are the perpendicular stresses.
ε_x, ε_y are the strains in corresponding directions.
E is Young's modulus for the material.
μ is Poisson's ratio.

It has been found convenient to use the standard form shown in Fig. 9 for carrying out these calculations.

The expressions for determining the magnitudes and directions of principal stresses from the three readings of a rosette gauge are a little more complicated than those above. Use is made of a semi-graphical method for rectangular rosettes based on the use of Mohr's circles of stress and strain. The method has been described by Dobie and Isaacs.† More recently this same method has been reduced to a nomogram, from which the magnitudes of the principal stresses can be obtained very rapidly. The expression for determining the direction of the principal stresses is, for a rectangular rosette, quite simple, and it has been found quickest to perform this operation numerically, again using a standard form, as shown in Fig. 10. The values of the principal stresses are obtained as above and are entered on the form for convenience. The nomogram is illustrated in Fig. 11. It can readily be drawn for any particular values of the elastic constants: Young's modulus and Poisson's ratio. Where many tests are to be performed on specimens with

† *Electric Resistance Strain Gauges*, English Universities Press, London, 1948.

Reduction of Strain Gauge Readings

Experiment No.	Specimen	Page No.	Run No. / Date
Pressure/Load	$\sigma_x = \frac{E}{1-\mu^2}(\varepsilon_x + \mu\varepsilon_y)$	$\sigma_y = \frac{E}{1-\mu^2}(\varepsilon_y + \mu\varepsilon_x)$	$E=$ $\mu=$ $\frac{E}{1-\mu^2}=$

(1) Gauge Nos.	(2) ε_x	(3) ε_y	(4) $\mu\varepsilon_y$	(5) (2)+(4)	(6) σ_x	(7) $\mu\varepsilon_x$	(8) (3)+(7)	(9) σ_y

Fig. 9—Standard form for calculation of stresses from strains in a bi-axial stress field

Reduction of Strain Gauge Readings

Experiment No.	Specimen	Page No.	Run No. / Date
Pressure/Load	$\theta = 2\tan^{-1}\left(\frac{2\varepsilon_y - (\varepsilon_a + \varepsilon_c)}{\varepsilon_a - \varepsilon_c}\right)$		

(1) Gauge Nos.	(2) ε_a	(3) ε_y	(4) ε_a	(5) $\varepsilon_a - \varepsilon_c$	(6) $2\varepsilon_y - (\varepsilon_a + \varepsilon_c)$	(7) (6)/(5)	(8) ½θ	(9) θ	(10) σ_1	(11) σ_2

Fig. 10—Standard form for rosette gauges. Principal stresses σ_1 and σ_2 are found graphically or from a nomogram

sensibly the same elastic constants, the use of the nomogram will lead to a considerable saving of time. To design a nomogram for any particular case, it should be noted that the scale for ε_y is double that for $(\varepsilon_x+\varepsilon_z)$, which is, in turn, double that for $(\varepsilon_x-\varepsilon_z)$. The stress scale is linear and can therefore be rapidly determined by calculating in the usual way the stress values for two sets of strain readings. In use, the steps are as follows.

Step 1.—The value of $(\varepsilon_x+\varepsilon_z)$ on the appropriate scale is joined to the value of ε_y on its scale by a straight line.

Step 2.—The value of $(\varepsilon_x-\varepsilon_z)$ on the appropriate scale is joined by another straight line to the intersection of the first straight line with the central vertical line.

Step 3.—The length of the line obtained in Step 2 is multiplied by a constant (1·07) either by the use of the inset diagram or, more conveniently, by the use of proportional dividers.

Step 4.—The length from Step 3 is added and subtracted to the value of $(\varepsilon_x+\varepsilon_z)$, and the corresponding values of stress read off on the appropriate scale. An extended explanation of the design of the nomogram is given in the Appendix.

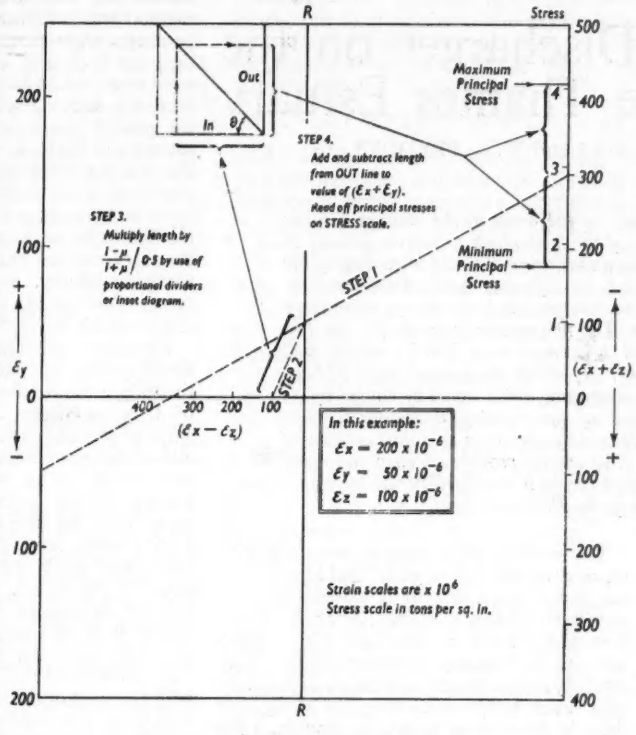


Fig. 11—Rectangular rosette nomogram

Appendix

Dobie and Isaacs give a graphical method for determining principal stress magnitudes and directions from the readings of a three-arm rectangular rosette. The method is based on the use of Mohr's circles of stress and strain, which are drawn with the same pole O and a common centre W. They show that, to obtain this condition,

$$\frac{\text{Scale for stress circle}}{\text{Scale for strain circle}}=\frac{E}{1-\mu}$$

and that the radius of the stress circle is $\frac{1-\mu}{1+\mu}$ times that of the strain circle.

Dobie and Isaacs' construction consists of the following steps :—

(1) Locate the centre W of the circles, from $OW=\frac{1}{2}(\varepsilon_x+\varepsilon_z)$.

(2) Measure off $ON=\varepsilon_y$, and erect the perpendicular $NM=\frac{1}{2}(\varepsilon_x-\varepsilon_z)$.

(3) Then M is a point on the strain circle whose centre is W.

(4) Draw the stress circle with centre W and radius $\frac{1-\mu}{1+\mu}WM$.

(5) Read off principal stresses OY and OX, whatever scale was used for strain being multiplied by $\frac{E}{1-\mu}$ to give stresses.

This approach lends itself to the construction of a nomogram, which, for fixed values of E and μ, is simpler than most similar nomograms, and is more rapid than actually drawing the Mohr's circles.

It will be seen from Fig. 11 that the nomogram is not complicated. The scale for ε_y is twice that used for the $(\varepsilon_x+\varepsilon_z)$ scale. The ε_y scale reads positive upwards, the $(\varepsilon_x+\varepsilon_z)$ scale positive downwards. Connecting the appropriate values on these two scales, therefore, gives $\frac{1}{2}\left(\varepsilon_y-\frac{\varepsilon_x+\varepsilon_z}{2}\right)$ as the intercept on line RR. That is, the intercept on RR is equal to $\frac{1}{2}$ WN. The scale for $(\varepsilon_x-\varepsilon_z)$ is perpendicular to those for ε_y and $(\varepsilon_x+\varepsilon_z)$ and is drawn to half the scale used for $(\varepsilon_x+\varepsilon_z)$. Joining the intercept on line RR to the appropriate value on the $(\varepsilon_x-\varepsilon_z)$ scale, therefore, gives a line equal in length to $\sqrt{\{(\frac{1}{2}WN)^2+[\frac{1}{2}(\varepsilon_x-\varepsilon_z)]^2\}}=\sqrt{\{(\frac{1}{2}WN)^2+(\frac{1}{2}NM)^2\}}=\frac{1}{2}WM$. The multiplying factor is given by $\left(\frac{1-\mu}{1+\mu}\right)/0{\cdot}5$. This multiplication is conveniently made by the use of proportional dividers, or by the small inset diagram in which the slope of the line is $\tan^{-1}\left(\frac{1-\mu}{1+\mu}\right)/0{\cdot}5$. This multiplication gives the correction for the ratio between the radii of the stress and strain circles $\left(\frac{1-\mu}{1+\mu}\right)$. The fraction 0·5 appears in the denominator owing to the fact that the length of the radius of the strain circle (WM) was halved.

The length found as above is now added and subtracted to the appropriate value on the $(\varepsilon_x+\varepsilon_y)$ scale, and the principal stresses read off against the adjoining stress scale. The ratio between the scale used for stress and that used for $\varepsilon_x+\varepsilon_z$ is $\frac{E}{2(1-\mu)}$. Taking $E=13{,}400$ tons per square inch and $\mu=0{\cdot}3$, this ratio is 1·044 : 1. The figure 2 appears in the denominator of this ratio since the basic quantity, to which is added and subtracted the radius of the stress circle, is half $(\varepsilon_x+\varepsilon_z)$.

Machine Tool Research Project

We have received from the Machine Tool Trades Association a copy of a note recently presented to the Machine Tool Advisory Council which outlines the aims of a machine tool project being sponsored by the National Research Development Corporation at the Manchester College of Technology. In view of the interest attaching to the note we reprint it in full.

Very few machine tools approach in operation the overall speeds of which they are potentially capable. The exceptions are, in general, those machines engaged on the mass production of identical parts—for example, automatic lathes and transfer machines. On most other machines making one-offs or small batches time is lost in setting up, loading and unloading, and, most important of all, in the inspection of the work-piece and while the operator refers to his drawing. Some of this time could be saved if automatic controls, replacing some or all of these functions, could be applied to the machine tool. It is also possible to save manpower by the automatic sequence control of a series of operations, thereby enabling the operator to supervise a number of the machines instead of being tied to the manual operation of a single machine. It is well known that a number of leading firms in this country have developed automatic measurement and control techniques and have applied them to a range of machine tools, notably horizontal borers, jig borers and contour milling machines. The control systems which have been developed are on the whole capable of measuring to extremely fine limits and of controlling movements at high speeds and accelerations. But it has been found that the mechanical design of the machine tool itself is the major limiting factor, both in obtaining the accuracy and running at the outputs of which the automatic control is potentially capable. Although individual firms in this country and overseas are tackling vigorously the mechanical problems encountered in the particular types of machine tool with which they are concerned, the Corporation believes that there is scope for a more general investigation of the mechanical elements which go to make up a machine tool. It is this conclusion which led to the setting up of the project at the Manchester College.

The Department of Mechanical Engineering at the Manchester College of Science and Technology is well equipped to undertake practical research in this field. They have on the spot a first-class metrology section and the help of other departments, notably in electrical engineering and electronics, is readily available. The work is under the direct supervision of the Senior Lecturer in Production Engineering, Dr. F. Koenigsberger, who has had wide academic and industrial experience. He has a growing staff of full-time qualified engineers, draughtsmen and fitters under him, and they will have very shortly the complete use of the Royce Laboratory, giving them a floor space of about 8000 square feet for their work.

The National Research Development Corporation, a public body set up by the Development of Inventions Act of 1948, has been closely concerned with electronic computers and, in the field of measurement, with the replication of diffraction gratings and the design of coded commutators. The work at the Manchester College is a logical extension of these interests. The N.R.D.C. is at present bearing the entire cost of the project. To help the corporation in the direction of this work a number of leading people in the machine tool, electronic and aircraft industries have been invited to serve on an advisory panel which meets from time to time.

It is the corporation's intention to make the results of this work available in the form of test reports and design data to all interested firms in those branches of British industry concerned with the design or use of machine tools. The corporation will also negotiate licences for the use of any inventions arising from the work at Manchester. A number of steps have already been taken, chiefly through the trades associations, to ensure that results can become widely known with the minimum of delay.

Effects of Heated Discharges on the Temperature of the Thames Estuary

By A. L. H. GAMESON, H. HALL and W. S. PREDDY*

No. I

A recent theory of the mixing and movement of the water of the Thames Estuary has been used to calculate the distribution of the heat which enters the estuary in heated discharges. By making simple assumptions about the rate of cooling of the water, which has not been directly measured, the difference between the temperature of the water during recent years and that during the last century, when there was little artificial heating, is calculated. The temperature records for the two periods was examined, and the calculated differences were found to agree well with the observed differences. It is shown that, within the normal range of temperature of the estuary, the increase of temperature which would be caused by an increased discharge of heat is independent of the existing temperature. The increases of temperature which would be caused by the entry of a unit amount of heat at various positions are calculated. The results provide an easy and rapid method of estimating the changes of temperature which would follow any alteration in the amount or position of the discharged heat.

IN the course of an investigation of the pollution of the Thames Estuary it was realised that temperature might be an important factor affecting the condition of the water.[1] A number of electricity generating stations use the water of the estuary for cooling purposes and reject large quantities of heat to it. Calculation of the effects produced by the installation of new plant, or by changes in the discharge of heat from existing stations, requires a knowledge of the rate of exchange of heat between the water of the estuary and the air above it.

To find this rate of exchange of heat it is necessary to know how much the temperature has been raised by the heating, and, consequently, to know also what would have been the temperature in the absence of the heated discharges. This basic temperature depends on various meteorological factors, but it was thought that in any particular quarter of the year the relation between air and water temperatures might well be much the same from one year to another. Accordingly, an examination was made of the relations between the air temperature and the water temperature during periods when the artificial heating of the estuary was slight. The relations found were by no means precise, but the consistency of the results of calculations in which they have been used indicate that they are as accurate as can be expected.

Examination of the problem falls into five sections : measurement of the temperature of the water of the estuary over a period of several years ; estimation of the temperatures that would have existed during the same period if no heat had been discharged ; examination of the rate of entry of heat to the estuary ; calculation of the rate of loss of excess temperature ; and prediction of the temperature distribution for unit inputs of heat at points throughout the estuary.

Temperature in Presence of Heated Discharges

From 1949 to 1954 the temperature of the water of the Thames Estuary was measured from the Port of London Authority's launch "Shornmead" in the course of chemical surveys made by the Water Pollution Research Laboratory. These surveys were carried out weekly (except when the launch was being overhauled) and temperatures were taken at a depth of 6ft, in mid-stream, at fifteen or more points from some miles above London Bridge to Southend—a total distance of about 50 miles.

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The earliest measurements were made by placing a mercury-in-glass thermometer in the water remaining in a Casella sampler (a weighted brass container) after the bottle it contained had been removed. This method tends to give slightly erroneous results—particularly in the winter when the air is generally at a lower temperature than the water and there is also cooling by evaporation from the wet sampler while the measurement is being made.

In 1951, a method of measuring the temperature electrically was developed,[2] use being made of thermally sensitive resistors formed from a complex mixture of metallic oxides ; the resistors chosen were Stantel thermistors, type F2311/300.[3] The general use of thermistors in measuring water temperatures has been discussed in detail by Mortimer and Moore.[4] Although the apparatus to be used in the estuary was developed in 1951 it did not supersede the mercury thermometers until November, 1952 ; thereafter it was periodically calibrated in the laboratory against an accurate mercury-in-glass thermometer. On two occasions in that month, when a total of forty-eight temperatures in the estuary were measured, both with a thermistor and with a mercury thermometer, the values obtained with the thermistor exceeded those found with the thermometer by an average of 0·09 deg. Cent. with a standard deviation of 0·14 deg. Cent.

The average period of retention of the fresh water passing through the estuary is of the order of a month, and since the thermal capacity of the water is large and the rate of cooling is comparatively slow, it is considered best to make the calculations using average figures for a period of a few months. A period of three months was found to be the most suitable.

An effluent entering the estuary is not only displaced toward the sea by the fresh water flow, and dispersed by tidal mixing, but is also carried some way up and down the estuary under the action of the tide. The average range of this tidal excursion in the part of the estuary being considered is 8 or 9 miles, and it is evident that in obtaining the quarterly average distribution of temperature along the estuary it is essential to reduce all the figures to some common basis of tidal state. If there were a large number of temperatures taken at all states of the tide at one point in the estuary, the average temperature at that point could readily be found, but when there are only about thirteen readings taken at any point during the quarter this method is unsuitable, and consequently a different method was adopted. The individual temperatures were plotted against the position that the bodies of water from which they were taken would have occupied at half-tide ; then, by drawing a smooth curve through the plotted points, the distribution of temperature at half-tide was found. To obtain the average distribution during the quarter, the temperature was read from each weekly curve at intervals of 5 miles along the estuary, the figures for each point were averaged, and the average values plotted against the distance along the estuary. It may be mentioned that this method has also been applied successfully to figures for salinity[5] and oxygen.[1]

Variation of Temperature Across the Estuary.—In the part of the estuary lying roughly in the 8 miles immediately upstream of London Bridge the temperature of the water at the side of the estuary is often appreciably different from that of the water in the centre. The power stations in this neighbourhood discharge their condenser water near the side of the estuary and the heated water flows close to the bank for a number of miles, gradually mixing with the water in the centre. The difference in temperature is greatest just below the point of discharge from a large power station on the ebb tide, and just above it on the flood. The temperature difference varies greatly with the state of the tide, and if the positions where the temperature is measured in mid-stream are adjusted to the half-tide positions it is found that the temperature depends on the state of the tide.

Only a few measurements of these variations in temperature across the estuary were made during the survey, and the available information is insufficient for applying an accurate adjustment of mid-stream data to average conditions over the cross-section. The temperature of the water at the centres of the arches of the bridges in this neighbourhood was measured from time to time, but there was no measurement of the amounts of water flowing through the different arches. To apply a correction it is necessary to estimate the temperature which would have obtained if the water had been completely mixed, and to find this accurately requires a knowledge of all the temperatures and all the velocities of flow in a cross-section. The relative discharges through the different arches were not measured, but were estimated approximately from the width of the arches, the depth of the water under them, and from the visible movement of the surface. The required average temperature of the water over the cross-section was then estimated. The corrections to be applied to the mid-stream temperatures were adjusted to half-tide positions and the average correction at each position was found ; there were large variations in the calculated corrections. Fortunately the variation in temperature had been measured for the same tidal conditions as those when the temperature readings in the centre of the estuary had been taken and are therefore representative of the same tidal conditions. The maximum correction which was used was less than 1 deg. Cent.

Temperature in Absence of Heated Discharges

It is to be expected that the average temperature of the water near the head of the estuary will be related, fairly closely, to the prevailing air temperature, while at the seaward end the temperature of the water will be determined mainly by that of the sea. Owing to its large thermal capacity the sea changes temperature only slowly, and consequently the changes in the temperature

of the water at the bottom end of the estuary tend to lag behind changes in air temperature. The differences between the mean temperature at the surface of the water near the mouth of the estuary and the mean air temperature at Greenwich during each month of 1930 are shown in Fig. 1.

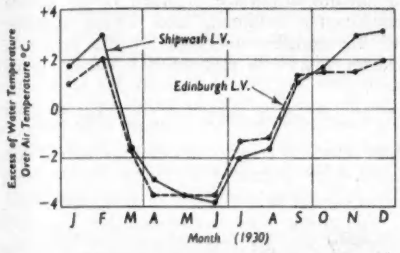


Fig. 1—Comparison between monthly average temperatures of the sea at two lightvessels in the mouth of the Thames Estuary and of the air at Greenwich

The average temperature of the water at any point in an estuary receiving no heated discharges will not, in general, be the same as that of the air in contact with it. The water temperature will be lowered by evaporative cooling and raised as the result of insolation; there will also be exchanges of heat with adjacent bodies of water and with the bed of the estuary.

In the present work it was decided that the labour involved in calculating the equilibrium temperature of the water—on the basis of the humidity, temperature, wind velocity, intensity of sunshine, &c.—would be excessive, and that the results obtained thereby would be of doubtful accuracy. Instead, the relations that existed between the air and water temperatures before the estuary was appreciably heated were derived from the earliest apparently reliable data that could be found. Some data were found for the temperature near Teddington Weir which forms the landward limit of the estuary. Figures were also obtained for two points in the middle reaches—at Greenwich (23 miles seaward of Teddington Weir), and off Crossness (32 miles).† The temperature distribution seaward of Crossness was found from measurements made by the London County Council in the course of their regular chemical surveys.

Temperature at Teddington.—The earliest data found for the temperature of the Thames in the vicinity of Teddington are for January 1855 to June 1857.[6] These data give the temperature of the water measured daily at 9 a.m. at Kingston-on-Thames (about a mile upstream of Teddington) and recorded to 1 deg. Fah.—or sometimes to half a degree.

The monthly averages of these temperatures have been compared with the corresponding averages of the daily mean air temperature recorded at Greenwich Observatory (obtained from the Meteorological Office of the Air Ministry). A preliminary investigation showed that in all but one of the months the temperature of the water exceeded that of the air, and that the excess temperature tended to increase with increasing temperature. In the subsequent analysis the values for February 1857 were omitted since the average air temperature was −1·6 deg. Cent. which would lead to an expected water temperature of less than 0 deg. Cent.

A partial regression equation was derived giving the predicted value, T'_w, of the temperature of the water in terms of the air temperature T_a, and the difference, A, between the value of T_a and its value in the previous month. The term in A was included in case the temperature of the water tended to lag behind that of the air. The equation for the predicted value of the water temperature was then found to be

$$T'_w = 1{\cdot}64 + 1{\cdot}072T_a + 0{\cdot}011A \quad . \quad . \quad (1)$$

where all the temperatures are in degrees Centigrade. The coefficient of A in this equation suggests a negative lag effect but it is not statistically significant.

The standard error of estimate was 0·56 deg. Cent., compared with an error of 0·68 deg. Cent. for the simpler equation $T'_w = T_a + 1{\cdot}27$, and with a standard deviation of over 5 deg. Cent. in the observed values of T_w.

It may be noted that since the water and air temperatures are so closely related, this and subsequent regression work has been carried out using the excess temperature instead of the water temperature, that is an equation of the form $(T'_w - T_a) = a + bT_a + cA$ has been obtained, and then rearranged to give the water temperature in the form

$$T'_w = a + (1+b)T_a + cA.$$

Using the regression equations to predict the water temperature in February 1857 the value found for T'_w is −1·13 deg. Cent. while the observed value was 0·64 deg. Cent. which gives an error in prediction over three times the standard error; this is highly significant and indicates that the equation does not apply when such low air temperatures are encountered.

From 1915 to 1921 the temperature of the Thames at Teddington was measured, once every two weeks, by the London County Council; since 1944 these measurements have been continued. If the quarterly averages of the L.C.C. readings for Teddington during the period from 1915 to 1921 are compared with the values given by the equation for Kingston, it is found that the standard error in prediction is 0·68 deg. Cent., and that the average error is +0·05 deg. Cent.; this shows that the observed and predicted levels of the water temperature do not differ significantly. Since there are only about six readings for each quarter it is impossible to predict the observed values with any great accuracy, as these values will not necessarily be representative of the average temperature during the quarter. If the readings for 1944 to 1948 are included, the average and standard errors remain unaltered (figures for more recent years have not been used owing to the discharge of heat from Kingston Power Station). Now the standard deviation of the observed excess of the temperature of the water over that of the air is found to be only 0·69 deg. Cent., so that the regression equation has no advantage over adding a constant amount to the air temperature to obtain the water temperature. The average observed excess for the four quarters of the year are 0·7 deg., 1·8 deg., 1·3 deg., and 1·4 deg. Cent., respectively.

Lacking more detailed information, the quarterly average temperature T'_T, of the Thames at Teddington, in the absence of artificial heating, will be assumed to be given by

$$T'_T = T_a + a \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where T_a is the corresponding average for the air temperature at Greenwich, and a is equal to 0·7 deg., 1·8 deg., 1·3 deg., or 1·4 deg. Cent. for the first to fourth quarters of the year respectively.

Temperature at Greenwich.—During most of the latter half of the nineteenth century the temperature of the estuary in the neighbourhood of Greenwich was recorded daily.[7]

The earliest readings were taken using a maximum thermometer (mercury in glass, with a steel index) and a minimum thermometer (coloured alcohol in glass, with a glass index). The thermometers were placed in a perforated wooden trunk fixed to the side of the "Dreadnought" Hospital Ship in such a way that the thermometers were about 2ft below the surface of the water and 1ft from the bottom of the trunk. The thermometers were read daily by the superintendent of the ship or, in his absence, by one of the officers. The daily readings began on May 13, 1844 after a preliminary experiment had shown that there was no appreciable vertical temperature gradient in the estuary at this point.

The records give the daily readings of each thermometer, and also the monthly averages except for 1844, 1845, and 1848 to 1855. From 1866 the index-error corrections to the thermometers are recorded; it appears that the corrections have been applied. On April 13, 1870, the readings were discontinued as "Dreadnought" ceased to be used as a hospital ship. Nine months later the trunk containing the thermometers was attached to the police ship "Scorpion" moored in Blackwall Reach, and observations were made by the resident inspector on board. In April 1872, the miminum thermometer was broken and replaced—this is the first mention of a change in thermometers. In May 1874, the trunk was moved from the "Scorpion" to the "Royalist" moored in the same place. In February 1875, both thermometers were replaced. In October 1879, the police ship "Royalist" was involved in a collision and placed on the bank, and the series of readings then terminated owing to the inability to find a suitable station for the thermometers.

In May, 1883, the recording of Thames temperatures was resumed under the direction of the Corporation of the City of London. A Six's thermometer was placed 2ft below the surface of the water at the end of one of the jetties of the Foreign Cattle Market at Deptford (4 miles below London Bridge). This series went on for eight years and the last readings were taken on June 13, 1891.

The Greenwich–Deptford readings therefore cover most of the period from 1844 to 1891, and those for 1856 onwards have been examined statistically in the same way as were the figures for Kingston. Groups of from three to five years have been taken, and partial regression equations obtained giving the excess of the temperature of the water over that of the air, in terms of the air temperature T_a, and the change A, in the value of T_a from the previous month. After rearranging, equations are obtained of the form

$$T'_w = a + b_1T_a + b_2A \quad . \quad . \quad . \quad (3)$$

The values of the coefficients b_1, b_2 and their standard errors of estimate are given in Table I:

TABLE I—*Coefficients (and Standard Errors) in the Equation* $T'_w = a + b_1T_a + b_2A$, *where* T'_w *is the Estimated Temperature of the Water,* T_a *the Air Temperature, and A the change in* T_a *from the Previous Month;* S_b *is the Standard Error of b*

Position	Period	$b_1 \pm S_{b_1}$	$b_2 \pm S_{b_2}$
Greenwich ...	1856–59	1·087±0·022	−0·153±0·037
Greenwich ...	1860–63	1·125±0·030	−0·169±0·046
Greenwich ...	1864–66	1·086±0·034	−0·092±0·050
Greenwich ...	1867–70	1·054±0·024	−0·126±0·034
Greenwich ...	1871–75	1·140±0·023	−0·191±0·033
Greenwich ...	1876–79	1·084±0·022	−0·106±0·036
Deptford ...	1883–86	1·111±0·027	−0·130±0·045
Deptford ...	1887–91	1·069±0·023	−0·179±0·035

In Fig. 2 are drawn the regression lines for conditions when A is zero; the figure thus shows the excess of the water temperature over that of the air when the air temperature

† Positions in the estuary are generally given with reference to London Bridge, which lies 19 miles below Teddington Weir.

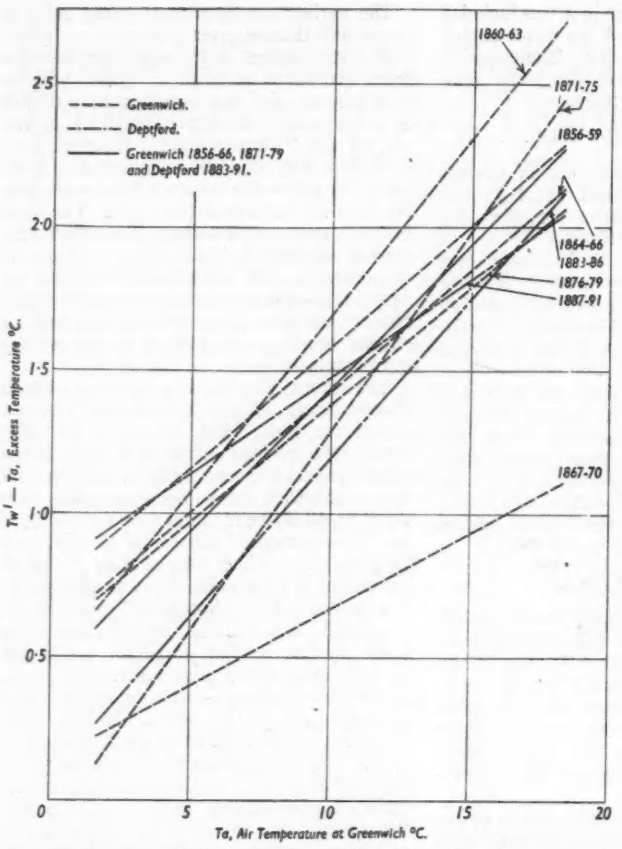


Fig. 2—Relation between the air temperature when this is steady and excess of water temperature over air temperature. Data from Table I with A put equal to zero

is steady—or, more precisely, the average excess to be expected during the second of two months with the same average air temperature. The line for 1867–70 lies below the other lines to an extent that is statistically significant as the standard error of the mean excess temperature for this group is 0·11 deg. Cent. The other lines lie close together, and although both the value of b_1 and of b_2 are rather higher for 1871–75 than for the other groups, the discrepancy is not large enough to conclude that the readings of this group do not come from the same population as the remaining data. Since there is no reason to suppose that the excess temperature was actually half a degree lower during the years from 1867 to 1870 than during the rest of the period, and since the remainder of the lines agree well with those for Kingston from 1855 to 1857, and for Crossness from 1885 to 1895 (see below), it is assumed that the readings for 1867 to 1870 contain some systematic error. The data for Greenwich in 1856–66 and 1871–79, and for Deptford in 1883–91, have been taken together, and the regression equation calculated as before. The equation for estimating the water temperature T_w is found to be :

$$T'_w = 0{\cdot}41 + 1{\cdot}101T_a - 0{\cdot}151A \text{ deg. Cent.}$$

Although the coefficients in the regression equations for the different groups are substantially the same, the relations may not, in fact be linear. Since an equation is required for predicting quarterly averages, it is advisable to see whether or not the mean errors for corresponding quarters differ significantly from zero. Taking all the quarterly averages that are available for the period 1856–66 and 1871–91 the average errors for the four quarters are found to be +0·20 deg., −0·48 deg., +0·10 deg. and +0·16 deg. Cent. respectively. Now the population standard deviation of all the errors in the seventy-eight quarters used is equal to $\sqrt{\Sigma(T'_w - T_w)^2/77}$, or 0·50 deg. Cent. and for a group of twenty figures for corresponding quarters the standard error of estimate of the mean temperature will be $0{\cdot}50/\sqrt{20}$, or 0·11 deg. Cent. Accordingly, the average error of −0·48 deg. Cent. for second quarters must be considered to indicate that the true relation between T_w and T_a is not linear or that there is some other difference between this and the other quarters of the year.

The most suitable equation for the prediction of the temperature T_θ, of the water in the vicinity of Greenwich and Deptford is therefore concluded to be

$$T'_\theta = a + 1{\cdot}101T_a - 0{\cdot}151A \text{ deg. Cent.} \quad . \; . \; (4)$$

where a is 0·21 deg., 0·89 deg., 0·31 deg., or 0·25 deg. Cent. for the first to fourth quarters respectively, T_a is the mean air temperature at Greenwich, and A is the average month-to-month change in T_a—that is, one-third of the difference between the value of T_a in the last month of the quarter and the last month of the preceding quarter. The standard error for the seventy-eight quarters using the four forms of this equation is 0·40 deg. Cent.

Temperature off Crossness.—The regular recording of the temperature of the water of the Thames by the London County Council appears to have started in February, 1885. From that date the series of readings for the Thames off Crossness—about 13 miles seaward of London Bridge—is almost complete. The temperatures are taken twice daily (once near high water and once near low water), in midstream at a depth of 6ft. Readings are not taken on Sundays, on public holidays or in unsuitable weather.

The monthly averages have been treated in the same way as above. Dividing the data for 1885 to 1895 into three groups showed no significant difference between values of the coefficients obtained, and taking together all the monthly averages for the period of eleven years the regression equation found was.

$$T'_w = 0{\cdot}40 + 1{\cdot}098T_a - 0{\cdot}272A \text{ deg. Cent.}$$

The standard error of estimate was 0·57 deg. Cent.—for quarterly averages the expected error would be $0{\cdot}57/\sqrt{3}$, or 0·33 deg. Cent.

To check the equation, the quarterly averages of the temperature off Southern Outfall (Crossness) in 1912 to 1918 have been compared with the values given by the equation. The average error was found to be −0·04 deg. Cent. and the standard error 0·42 deg. Cent.

Once again the average errors in the prediction by quarters have been calculated. Taking the errors for Crossness in 1885-95 and Southern Outfall in 1912-18, the average values for the four quarters are +0·26 deg., −0·18 deg., +0·12 deg., and −0·08 deg. Cent., respectively. After adjusting the equation to offset these errors, the standard error of prediction of the sixty-two quarterly averages is 0·36 deg. Cent.

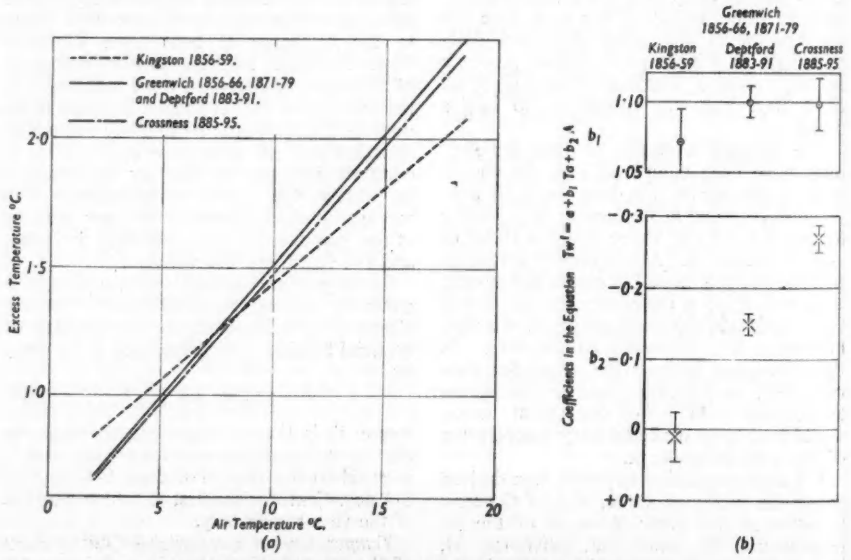
The equation that will be used for predicting the temperature, T_c, of the estuary 13 miles below London Bridge is therefore :

$$T'_c = a + 1{\cdot}098T_a - 0{\cdot}272A \text{ deg. Cent.} \quad . \; (5)$$

where a is 0·14 deg., 0·58 deg., 0·28 deg., or 0·48 deg. Cent. for the first to fourth quarters respectively.

Comparison of Regression Equations for Three Stations.—It is of interest to compare the regression equations for the three independent sets of data for Kingston, Greenwich and Deptford, and Crossness. The results of the comparison are shown in Table II and Fig. 3.

The closeness of the lines in Fig. 3(*a*) is remarkable, and shows that under conditions of steady air temperature (A equal to zero), the temperature at these three stations was nearly the same. In Fig. 3(*b*) it may be seen that while the values of b_1 do not differ significantly between the three sets of data,



(*a*) Combined results of Fig. 2 compared with data for Kingston and Crossness.
(*b*) Coefficients in Equation (3) for three points in the estuary. The vertical lines show the range $(b+Sb)$ to $(b-Sb)$ where Sb is the standard error of estimate b.

Fig. 3—Relation between the temperature of the Thames and of the air at Greenwich

those for b_2 do—the further seaward the station, the more does the water temperature lag behind the air temperature.

Seaward of Crossness.—Temperature measurements of the sea used to be made from the Edinburgh Light Vessel (Lat. 51 deg. 33 min. North, Long. 01 deg. 16 min. East) which is about 76 miles seaward of London Bridge. This point should be far enough out to be unaffected by the artificial heating of the Thames but not so far out that conditions are likely to be very different from those in the lower reaches of the estuary. The readings relate to the temperature of the surface of the sea and were recorded twice daily—at or about sunrise, and at 4 p.m.; the temperatures are generally given to 1 deg. Fah.

Unfortunately no observations of sea temperature have been made from Edinburgh Light Vessel since May 1940. No attempt has been made to relate the available data to the air temperature at Greenwich. Since the war the nearest observing stations to the Thames have been Shipwash Light Vessel (52 deg. 02 min. North, 01 deg. 42 min. East) and Galloper Light Vessel (51 deg. 44 min. North, 01 deg. 58 min. East); both these vessels lie nearly 50 miles seaward of the Edinburgh and quarterly averages of sea temperature do not bear a simple relation

TABLE II—*Coefficients (and Standard Errors) in the Equation* $T'_w = a + b_1 T_a + b_2 A$, *where* T'_w *is the Estimated Temperature of the Water,* T_a *the Temperature of the Air at Greenwich, and A the Change in* T_a *from the Previous Month. Temperatures in Deg. Cent.*

Station	Kingston	{Greenwich Deptford}	Crossness
Miles from London Bridge	20 above	4 below	13 below
Period	1855–57	{1856–66 1871–79 1883–91}	1885–95
Number of monthly averages used in analysis	28	276	118
a	0·61	0·41	0·40
b_2	1·072	1·101	1·098
S_{b_1}	0·025	0·019	0·011
b_1	0·011	−0·151	−0·272
S_{b_2}	0·040	0·015	0·018
T'_w when $T_a=10$, $A=0$	11·33	11·42	11·38
T'_w when $T_a=20$, $A=0$	22·05	22·43	22·36

to each other (see, for example, Fig. 1), or in the pre-war period to those of the Edinburgh. It would appear that there are no suitable readings of sea temperature with which to compare the temperature of the estuary since the middle of 1940.

Accordingly, the distribution of temperature seaward of Crossness that would exist if no heat were discharged to the estuary has been assumed to be the same as existed dur

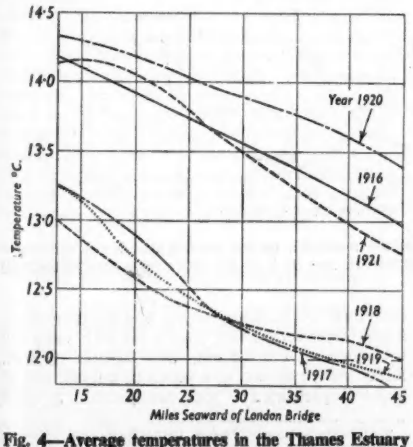


Fig. 4—Average temperatures in the Thames Estuary during the April-June quarters of 1916 to 1921

ing 1915 to 1921. This period was chosen because the frequent surveys of the estuary made by the L.C.C. started in 1915, and because it appears that the temperature of the estuary off Crossness began to rise appreciably soon after 1921.

Each quarter of the year was examined in turn. The average temperature at each sampling station was calculated from the L.C.C. data and plotted against the position in the estuary. Smooth curves were then drawn through each set of points and the temperature read off at intervals of 5 miles from 15 to 45 miles below London Bridge—the curves for the second quarters are shown in Fig. 4. The average change in temperature from Crossness to each 5-mile point was then found for all the corresponding quarters and the results plotted, as in Fig. 6. The period covered was from the fourth quarter of 1915 to the fourth quarter of

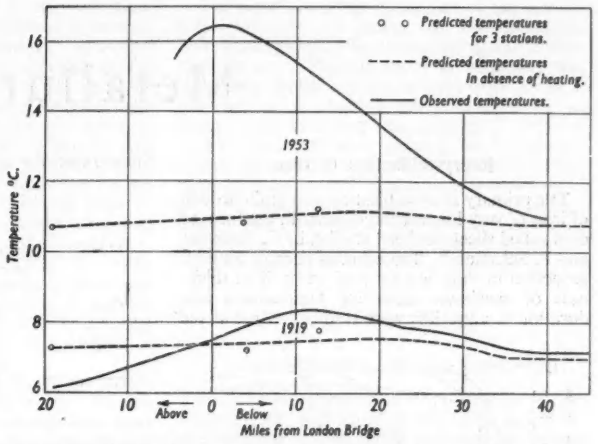


Fig. 5—Comparison between observed temperature of the Thames Estuary during the October-December quarters of 1919 and 1953 and the temperature calculated for the same quarters in the absence of artificial heating

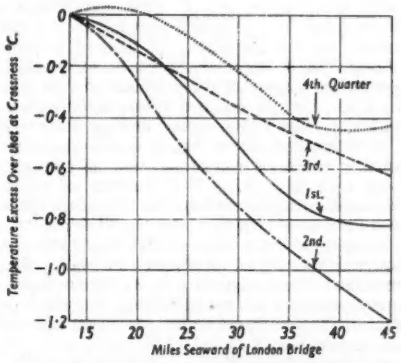


Fig. 6—Average distribution of water temperature seaward of Crossness during corresponding quarters of 1915 to 1921

1921, inclusive, but excluding the first quarter of 1920 for which there was insufficient information.

Production of Basic Temperature Curves.—To obtain a curve showing the temperature—which may conveniently be called the basic temperature—that would be found in the estuary under existing conditions of air temperature, if there were no discharge of heat to the estuary, the following procedure has been adopted. The predicted temperatures at Teddington, Greenwich and Crossness have been found by means of Equations (2), (3) and (4), respectively, and plotted against the position in the estuary. The appropriate curve from Fig. 6 has then been added, and a smooth curve drawn through the point for Teddington and between those for Greenwich and Crossness. Two examples of such curves are shown by the broken curves of Fig. 5 where curves for the observed temperature are also shown. It may be noted that the separation of the broken curves for 1919 and 1953 does not represent any general rise in temperature during the intervening years but only that the fourth quarter of 1953 happened to be warmer than the fourth quarter of 1919 by, on the average, some 3½ deg. Cent. The separation of the broken and continuous curves for the fourth quarter of 1953 shows the degree of heating of the estuary during that quarter, while the difference between the two curves for 1919 suggests some heating but indicates also the order of accuracy obtained in calculating the basic temperature from the air temperature; the accuracy of the observed data for 1919 is not known—the temperatures were recorded for the purpose of calculating the solubility of oxygen in the water and were not intended to show accurately the distribution of temperature through the estuary.

(To be continued)

Ship Service-Performance Trials

A PAPER entitled "Service-Performance Trials Carried Out in the North Atlantic on S.S. 'Cairndhu,'" was presented before the North East Coast Institution of Engineers and Shipbuilders by S. Livingston Smith, D.Sc. (Eng.), and R. E. Clements, B.Sc., on November 29.

This paper describes trials carried out by the British Shipbuilding Research Association in a dry cargo vessel under normal service conditions in the North Atlantic. The object was to study the performance of the vessel under different conditions in order to provide accurate data for comparing and developing methods of analysing service performance, power allowances, &c.

An important item in work is the trials instrumentation, the object being to obtain autographic records of as many items as possible. Shaft revolutions, wind speed and direction, rudder angle, angles of roll and pitch, and ship speed by pitometer log, were all recorded autographically. It was not possible to record propeller thrust and torque autographically, and for these measurements a Michell thrustmeter and Siemens-Ford torsionmeter were used. Estimates of wavelength and height during each observation were made visually and stereoscopic photographs were taken.

During each observation the power necessary to maintain the recorded speed was measured. This power was higher than that necessary to maintain the same speed in calm water and the percentage difference between these two powers has been estimated to give the percentage increase in power under the prevailing conditions. The effect of direction of encounter has been analysed in a similar manner. The loss of speed for a given shaft horsepower from the speed for the same power in calm water has also been estimated for each observation. Details are given of the weather encountered, ship motions during the trials; and of the velocity distribution within the boundary layer measured on the pitometer log.

Conclusions reached regarding power margins depend on the weather encountered by the vessel during the voyage and the condition of the hull, and an appendix gives details of the weather encountered by the vessel during the first year of service, and there is a brief analysis of the performance during this time made from data supplied by the ship's officers. Tables record weather data, ship motions and propulsion data for particular voyages.

Metallurgical Topics

Recrystallisation of Iron

THE primary recrystallisation and grain growth of iron of very low carbon content in the form of cold rolled sheet has been studied by F. Haessner and P. Schwaab.* The effect of carbon content, reduction in thickness by cold work, final thickness of specimen, annealing temperature and duration of annealing were studied. Most of the work was carried out on two samples of iron of relatively high purity and differing only in carbon content ("A" with 0·006 and "B" with 0·0015 per cent of carbon) but each containing 0·28 per cent of nickel. A third material "C" (carbon 0·003 per cent), almost free from nickel but containing higher sulphur and phosphorus and some other impurities, including aluminium, was used for comparison.

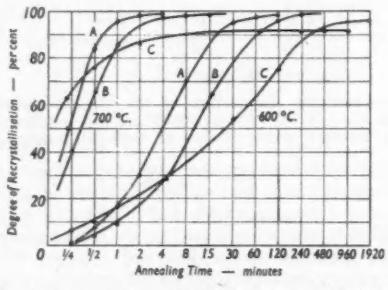
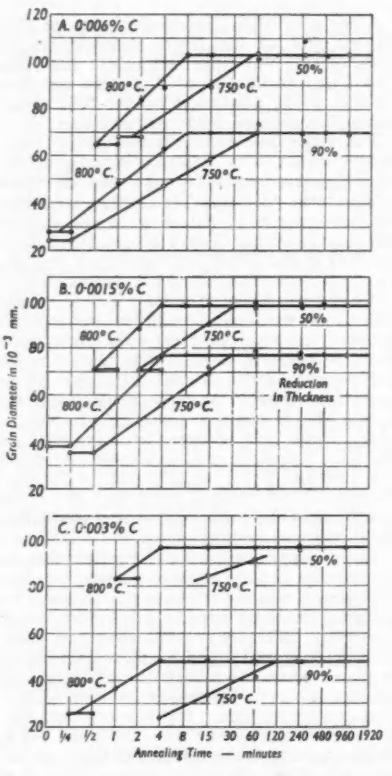


Fig. 1—Degree of recrystallisation of materials "A," "B" and "C," cold rolled 60 per cent, in relation to the time of annealing at 600 deg. and at 700 deg. Cent.



The curves for the materials cold rolled 70 per cent lay between those for 50 and 90 per cent and were the same for specimens of final thickness 0·3mm and 0·17mm.

Fig. 2—Effect of time of annealing at 750 deg. and at 800 deg. Cent. on the grain growth of materials "A," "B" and "C," cold rolled 50 per cent and 90 per cent to final thickness 0·3mm

The progress of recrystallisation was followed microscopically and by microhardness tests. In the cold worked material grains are elongated, and recrystallised grains differ in size and shape from the original grains deformed by cold work. The degree of recrystallisation could therefore be estimated by making a survey under the microscope, fitted with a measuring eyepiece, of 10 square millimetres of the surface. Recrystallised grains have a markedly lower hardness than those which have not recrystallised. Hardness tests were made with a Zeiss microhardness tester (load 50 *g*) at twenty-five suitably selected places on the specimen. If tests at n places showed that n_r impressions were on recrystallised grains, the degree of recrystallisation was taken as n_r/n. Results obtained in this way are shown in Fig. 1. The higher carbon content of material "A" resulted in a lower temperature and smaller range of recrystallisation as compared with material "B." The presence of carbon appeared to accelerate both the rate of formation and the rate of growth of nuclei. Material "C" recrystallised fully only at 800 deg. Cent. At lower temperatures, represented in Fig. 1, there remained, after a very long time of annealing, an unrecrystallised residue consisting of about 5 per cent of the whole, indicating some sort of arrest in nuclear growth, possibly due to the presence of aluminium as nitride.

Grain growth after final primary recrystallisation diminished in rate with increasing time of annealing, and finally ceased entirely after a time dependent on the material and the annealing temperature. The final grain size arrived at depended only on the material and on the reduction in thickness that it had undergone. It did not depend on the temperature of annealing or on the thickness of the specimen. This is shown by the data given in the table and is illustrated in Fig. 2. Grain growth after the conclusion of primary recrystallisation was studied in all three materials in specimens of final thickness 0·30mm, which had undergone thickness reductions of 50, 70 and 90 per cent by cold work, and also in specimens 0·17mm thick after 70 per cent reduction by cold work. The annealing temperatures chosen were 750 deg. and 800 deg. Cent. At lower temperatures grain growth occurred very slowly. It will be seen that for a given material the time during which grain growth continued depended only on the temperature of annealing and not on the amount of cold work applied before recrystallisation; and also that for a given material the final grain size depended only on the amount of cold work and not on the annealing temperature. The increase in grain size brought about by annealing increased with increasing amount of cold work and was consistently greater in the material "A" with the higher carbon content than in material "B." These data are discussed and the conclusion drawn that grain growth is not determined exclusively by the surface energy of the crystals, but that residual disorder present in the primary recrystallisation structure is largely responsible. This would be greater the greater the deformation of the material before recrystallisation. It tends to disappear during grain growth. When this happens the growth stops if the surface tension is too small alone to give appreciable mobility to the grain boundaries.

Grain Diameters of the Primary Recrystallisation Structure Duration of Grain Growth and Final Grain Size of the Materials Studied after Different Amounts of Deformation

Material	Reduction in thickness, per cent	Thickness of specimen, mm	Grain diameter of primary recrystallisation structure		Duration of grain growth		Final grain size, 10^{-3}mm
			At 750 deg. Cent., 10^{-3}mm	At 800 deg. Cent., 10^{-3}mm	At 750 deg. Cent., min	At 800 deg. Cent., min	
"A"	50	0·3	68	66	60	8	102
	70	0·3, 0·17	46	42			85
	90	0·3	26	27			70
"B"	50	0·3	70	70	30	4	97
	70	0·3, 0·17	53	52			85
	90	0·3	39	39			75
"C"	50	0·3	—	85	120	4	96
	70	0·3, 0·17	—	55			68
	90	0·3	—	27			48

Residual Stresses in Case-Hardened Steel

IT is well recognised that residual compression stresses exist in the hardened surface layers of case-hardened steel, and that such stresses are beneficial when resistance to fatigue is required. The residual stress distribution in the carburised cases of a number of case-hardening steels has been reported by D. P. Koistinen,* who made use of the precision X-ray diffraction technique described by A. Christenson and E. Rowland.† Stress distribution was correlated with variation in structural constituents and carbon content. Results were shown in a series of curves, one of which represented "peak sharpness," a value

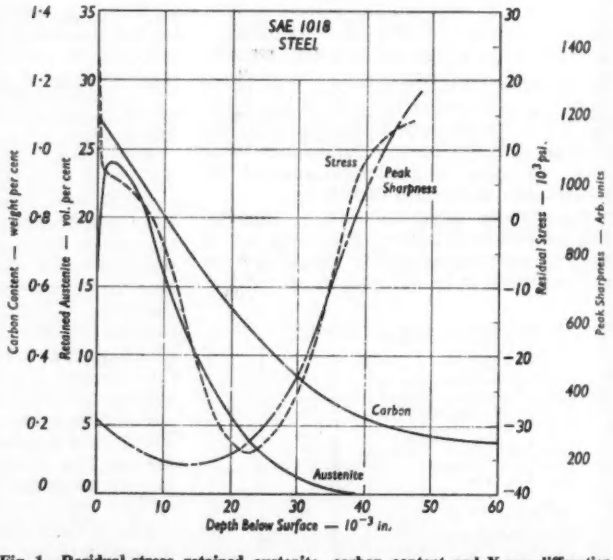


Fig. 1—Residual stress, retained austenite, carbon content and X-ray diffraction peak sharpness through a carburised case on 0·18 per cent carbon steel (Koistinen)

* *Archiv für das Eisenhüttenwesen*, September, 1957, page 583.

* American Society for Metals, 1957, Preprint No. 31.

† *Trans. Amer. Soc. for Metals*, 1953, Vol. 45, page 638.

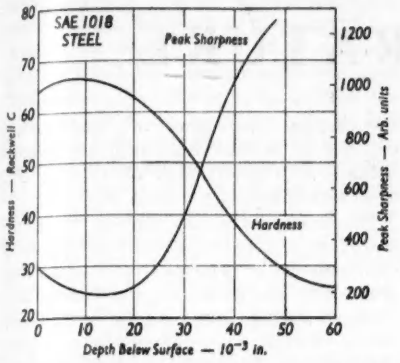


Fig. 2—Microhardness and X-ray diffraction peak sharpness through a carburised case on 0·18 per cent carbon steel (Koistinen)

which is inversely proportional to the width of the diffraction line. As the diffraction lines of tempered martensite are broad ("peak sharpness" low), while those of ferrite are narrow ("peak sharpness" high), the relative values of "peak sharpness" give an indication of hardness, as shown in Fig. 2. Maximum residual compression occurred at 50 to 60 per cent of the total case depth. In the example shown in Fig. 1 this corresponds to a carbon content of about 0·5 per cent. A similar distribution of stress was shown in the carburised case of a 1 per cent chromium steel (Fig. 3). The explanation put

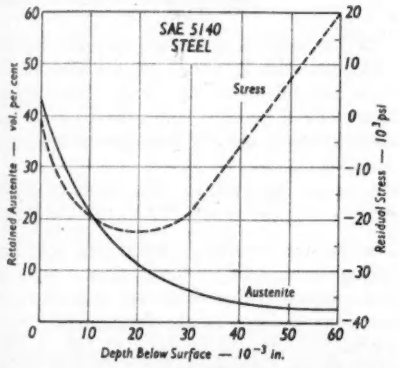


Fig. 3—Residual stress and retained austenite distribution through a carburised case on 0·4 per cent carbon, 1 per cent chromium steel (Koistinen)

forward is that the origin of the compressive stress in the case lies in the sequence in which transformations occur in the case and in the core. The introduction of carbon delays the martensite transformation in the case until after the core has transformed. The subsequent transformation and accompanying growth of the case is opposed by the previously transformed core resulting in compressive stresses in the case and tensile stresses in the core. The magnitude of the compressive stress in the case is governed by the extent of transformation to martensite. The reversal of sign of the residual stress from tension in the core to compression in the case occurs at or near to the case-core boundary; then, moving outwards, the stress becomes more compressive owing to the sequence of the transformations to isothermal transformation products or to martensite, and, finally, beyond the point of maximum compression, the compressive stress decreases as the amount of martensite is restricted by incomplete transformation of the austenite.

Blister Formation in Rolled Aluminium

THE formation of blisters on aluminium sheet has been a source of trouble for many years. The fact that the blisters make their appearance during the later stages of production means that much time and effort have been expended before it becomes evident that the material must be scrapped. The matter has been the subject of many investigations, but further work has been undertaken by J. H. O'Dette* to find out more about blistering and possible methods of control. He first describes the origin of blisters. Hydrogen gas is usually present in the cast ingot in the atomic or ionic form, in excess of the solid solubility. At room temperature the gas atoms are relatively immobile, but at elevated temperatures they become mobile and diffuse to free surfaces where they associate to form molecules. If these free surfaces are discontinuities within the ingot the gas molecules collect and build up considerable pressure until equilibrium is reached with the dissolved gas around the discontinuity, and large pressures may thus be built up. When the metal is rolled to sheet the presence of gas at these discontinuities is sufficient to deform the surface of the sheet and form a blister, particularly when the strength of the material is reduced as a result of annealing.

Results of O'Dette's experimental work supported this generally accepted view. Blister-raising discontinuities were located in sheet ingots and followed by means of non-destructive

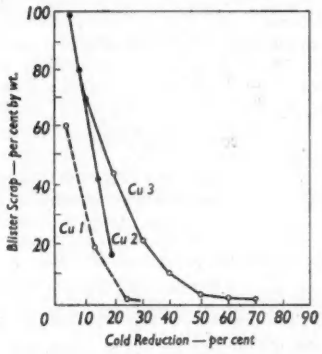


Fig. 1—Relationship between cold reduction of the ingot and blistering in aluminium alloy sheet

testing methods through the various stages of sheet production until blisters were actually formed. The internal free surfaces were shrinkage cavities and the problem became one of removing them at some temperature below that at which gas could readily diffuse into them. Although the gas is much less soluble in the solid than in the liquid metal, it does not follow that it will be rejected immediately by the liquid on freezing. In ordinary chill casting conditions the greater part of the gas remains in solid solution in the as-cast ingot. Rolling of ingots at room temperature proved to be a successful method of removing the cavities and reducing the tendency to form blisters (Fig. 1). By the

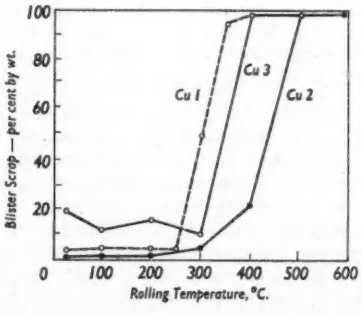


Fig. 2—Relationship between rolling temperature of the ingot and blistering in aluminium alloy sheet

cold welding of gas-free shrinkage cavities, brought about in this way, the free surfaces where the molecular gas might be formed were removed. If gas was allowed to accumulate in the cavities by reheating and rolling at temperatures above 250 deg. to 300 deg. Cent. welding of the surfaces was prevented and rolling at such temperatures was not shown to be effective in reducing blistering. This is shown in Fig. 2.

* *Journal of Metals*, July, 1957, page 924.

The closure and disappearance of the cavities were followed by means of the ultrasonic reflectroscope and also by sectioning and microradiography. The reduction of blistering was dependent on the amount of cold work given to the ingot up to about 40 per cent reduction, at which point blistering was reduced to approximately zero. Without ignoring the importance of gas removal from the molten metal, the author recommended the use of a technique based on at least 40 per cent cold reduction of the as-cast ingot, followed by the normal hot and cold rolling procedures. This proved to be the most effective of the methods tried for eliminating blisters.

Microstructures of Cast Crystals

ABOUT twenty years ago the Institute of British Foundrymen performed a valuable service to the industry by publishing two series of photographs illustrating typical microstructures of cast iron. It has now produced a new collection of photomicrographs to illustrate more recent developments in cast iron, and has extended the work to cover steel and non-ferrous castings. The photographs are accompanied by a description of the structures and a statement of the composition and mechanical properties of the material.*

In the non-ferrous section a valuable feature is the collection of photographs illustrating the effect of pouring temperature on the grain size of an aluminium alloy, and the character of defects due to inclusions or unsoundness such as blow-holes and shrinkage-porosity, oxide, silicate and sulphide inclusions in copper alloys, oxide and sand inclusions in aluminium alloys, flux inclusions and microporosity in magnesium alloys. In the steel section, on the other hand, the structures illustrated are confined to those of test bars cast 1½in thick. They do not represent the actual as-cast structure of massive steel castings, though the effect of heat-treatment and of alloy content on the structure and properties is well illustrated. The serviceability of a casting is, however, not entirely determined when a separately cast test bar meets specification requirements, and the value of the collection would have been enhanced if illustrations could have been given, as in the non-ferrous section, of defects to be avoided—for example, inclusions, undue segregation and porosity accompanied by local decarburisation. In the cast iron section also, the structures are typical of those obtained in cast test bars and do not necessarily represent commercial castings of greater cross sectional thickness. In this case, however, attention is directed to the effect of various forms of graphite and to the influence of phosphorus content, while illustrations are given of the characteristic structures of chilled cast iron rolls, of whiteheart, blackheart and perlitic malleable and spheroidal graphite cast irons, and of centrifugal castings. The extensive notes which accompany the structures of malleable and S.G. cast irons give a clear indication of the principles underlying their successful production.

The photomicrographs contained in the book are all of a high quality and the features which are referred to in the explanatory text may be readily identified. Standardisation of microstructure is a valuable, but in itself inadequate, means of quality control. As is stated in the preface, the photomicrographs provided do not necessarily represent the sole structure which will satisfy the specification.

An introductory section gives adequate advice about the preparation of specimens for microexamination, and includes directions for electrolytic polishing and for the use of diamond dust as well as an extensive list of etching reagents. The names of commercial suppliers of some of the equipment needed are recorded. This section should encourage the use of microscopical examination not only as an aid to control of quality, but also in the critical examination of trial castings and in the investigation of failures or defective material.

* *Typical Microstructures of Cast Metals*. Edited by G. Lambert. Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. Price 84s.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

EFFECT OF INERTIA ON WIDE ANGLE FLOW IN HYDRODYNAMIC LUBRICATION

SIR,—In your issue of September 27, 1957, on page 449, there appeared an article by J. F. Osterle and W. F. Hughes under the above title, in which the authors have offered a rather sketchy and incomplete mathematical argument intended to show that my approximate solution of the problem of hydrodynamic lubrication of the parallel sliding pad (W. Lewicki, THE ENGINEER, December 30, 1955, page 939) is in error because the effect of lubricant inertia has not been taken into account. The main point of objection against the authors' reasoning is that in the

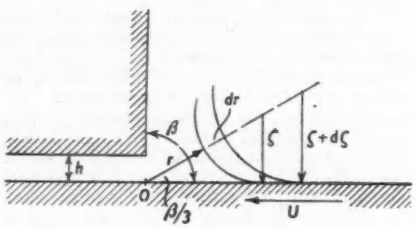


Fig. 1

disputed case there are really two distinct fluid wedges, which are coupled in series, and not just one as it would appear from their analysis. The parallel wedge, whose length was denoted by R by the authors, is ordinarily of the order of $1000h$ to $10{,}000h$, where h is the film thickness along the parallel part. The inflow region or the wide angle fluid wedge, to which the authors ought to have applied their argument, has its effective length of not more than $R=100h$. Consequently, if the latter value for R is inserted in their expression (4), the ratio F_i/F_0 becomes between a hundredth and a tenth of its supposed value. This hint is largely borne out by the following alternative calculation of the inertia effect, where the inertial pressure

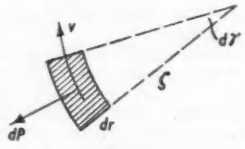


Fig. 2

build up at the leading edge of the slider is taken to be due to the centrifugal effect by the fluid in the wide angle wedge which is forced to move along curved paths.

The velocity of the flow perpendicularly to the radii r, which has been assumed to be nil for the purpose of my original analysis, within that theory can easily be shown to be, approximately,

$$v=\theta\left(\frac{\theta}{\beta}-1\right)^2 U \quad . \quad . \quad . \quad . \quad (1)$$

where θ is the direction angle of vector radius r in Fig. 1 and β is the total leading angle of the fluid wedge. Across the radius $\theta=\beta/3$, where the radial flow nullifies, by (1),

$$v=4\beta U/27 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Assume that the mean effective radius of curvature of the streamlines throughout the flow region is ζ as shown in Fig. 1, and that the elementary inertia reaction due to the change in direction of flow in the vicinity of the direction $\beta/3$ of a volume element (Fig. 2) is

$$dP=\rho Q v(d\gamma/2) \quad . \quad . \quad . \quad . \quad (3)$$

where ρ is the density of the lubricant, Q is the volume of flow in unit time and v is the cross-flow velocity given by (2). For the slice of fluid of unitary thickness in the region near the $\beta/3$ radius,

$$Q=v dr \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where, by Fig. 1,

$$dr=(\operatorname{cosec}(\beta/3)-1)d\zeta \quad . \quad . \quad . \quad (5)$$

Putting (2), (4), (5) into (3), and noting that the effective inertial pressure increment in the wide angle region is $dp=dP/\zeta d\gamma$,

$$dp=8(\operatorname{cosec}(\beta/3)-1)\beta^2\rho U^2 d\zeta/27^2\zeta \quad . \quad (6)$$

Assume that the effective length of the wide angle fluid wedge extends between $\zeta=h$ and $\zeta=100h$ and note that

$$\int_h^{100h} d\zeta/\zeta=\ln 100=4{\cdot}6052 \quad . \quad . \quad . \quad (7)$$

Assume now that the inertial increment of pressure all along the parallel portion of the slider is half the total inertial build-up at the leading edge of the underface. By (6), (7), the effective mean pressure increment under the sliding pad is, approximately,

$$p=0{\cdot}02527(\operatorname{cosec}(\beta/3)-1)\beta^2\rho U^2 \quad . \quad (8)$$

For the square-faced slider with a sharp leading edge, $\beta=\pi/2$, $\operatorname{cosec}(\beta/3)=2$,

$$p=0{\cdot}06235\rho U^2 \quad . \quad . \quad . \quad . \quad (9)$$

where ρ is the lubricant density and U is the velocity of sliding. Taking $\rho=0{\cdot}930$ gr/cc, by (9),

$U=$	1 m/s	10 m/s	100 m/s
$p=$	$0{\cdot}592$ gr/cm²	$59{\cdot}2$ gr/cm²	$5{\cdot}92$ kg/cm²

On account of the circumstance that neither the curvature of the streamlines nor the velocity of flow are really constants in the circumferential direction across the field of flow, there is a degree of uncertainty attached to the above calculation. However, it is believed that the true inertial increment of the mean pressure along the parallel (load-carrying) part of the sliding pad is between a half and twice the above amounts. Over and above this uncertainty, the effect of the actual depth of flooding with the lubricant is liable to have an effect. For instance, if the actual depth of the lubricant layer as it piles up against the leading face of the sliding pad is $10h$, where h is the film thickness under the parallel part, the above results should be halved ; if the actual depth is ten times the assumed $100h$, the results should be multiplied by $1{\cdot}5$, and if the depth is 100 times greater the results have to be doubled. It will be noted that according to the above calculations the inertial increment of load-carrying capacity is, on the whole, negligible, except perhaps at relatively high speeds of sliding or at exceedingly slight loads.

Returning now to the analysis by Osterle and Hughes, note one or two other points of doubt about the principles involved in their argument. To begin with, the authors have made an attempt at a quantitative treatment of the problem apparently by extrapolating their earlier numerical calculations of the effect of inertia at 6 deg. and still lesser convergencies to the region of convergencies as far removed as 90 deg. Besides, the consideration of average pressures $\bar{p}/\bar{p}_0$ along the walls delimiting the wide angle portion of flow is irrelevant in the disputed case, on the ground that $\bar{p}$ and $\bar{p}_0$ would, in any case, be both negligibly small in comparison with the mean pressure along the parallel portion, and on the ground that the effect of inertial pressure increment is not integral but direct, as already explained. Another point of doubt concerns authors' continuity equation (2). How is it possible to reconcile

$$\frac{\partial u}{\partial r}+\frac{u}{r}=0 \quad . \quad . \quad . \quad . \quad (10)$$

with the velocity u tending to be constant along the radii ? Could the authors please show how this equation arises ? It would be interesting if perhaps someone from among readers could offer a solution of authors' equation (1),

$$\frac{\partial p}{\partial r}=\frac{\mu}{r^2}\frac{\partial^2 u}{\partial\theta^2}-\rho u\frac{\partial u}{\partial r} \quad . \quad . \quad . \quad (11)$$

as a first step towards a more general solution, taking account of the cross flow. Note in this connection that so far we have no exact solution available of the fundamental non-inertial steady-state problem of the parallel or convergent sliding pad,

$$\nabla^4\psi=0 \quad . \quad . \quad . \quad . \quad (12)$$

which I have solved approximately, the parallel case in 1955 and the centrally loaded case in 1957. Unfortunately, exact solutions of equation (12) for an infinite plain fluid wedge without the gap at the narrow end offered by J. N. Goodier (*Phil. Mag.*, 1934 page 554), then by Blok (H. Blok, THE ENGINEER, August 31, 1956, page 304) and independently by Milne (A. A. Milne, Congr. Appl. Mech., Brussels, 1956 ; D.S.I.R.-L.D.R., 19/56) have proved to be of little help.

W. LEWICKI

London, N.W.5,
October 17, 1957.

THEORY OF SHAFT WHIRLING

SIR,—I have read with interest the articles by Dr. Downham on the theory of shaft whirling together with the letter by W. G. Crawford, and whilst agreeing with both of them that the theoretical approach of Captain Morris is more comprehensive than that of Dunkerley, I think some of the criticism of Dunkerley's work is unfair and unjust. In particular Dr. Downham writes in his first article (THE ENGINEER, October 11, page 519) " There are fallacies in Dunkerley's theo-

retical approach, especially when he attempted to account for the effect of rotor inertia . . . Ignoring the mass of the shaft he evolved a solution which again led him to erroneous conclusions. For the simple case of the cantilever shaft he predicted two critical speeds. A lower or ' inferior ' speed at which the effect of the inertia of the rotor was zero and a higher or ' superior ' speed at which the effect was infinite, the latter speed being twice the former. He concluded with the statement that . . . ' the period of whirling, corresponding to the inferior limit of speed, is identical with the natural period of vibration of the light shaft. . . ' ". This quotation from Dunkerley's article in the Philosophical Transactions of the Royal Society 1894 is not complete, the four omitted words " under the given conditions " referring only to the lower critical speed i.e. discs of negligible inertia ; for which conditions the statement is true. Furthermore, the two critical speeds referred to are not for one set of conditions, but the range of speeds within which the critical speed must lie for discs of the same mass but differing inertia. Finally the equation 13 developed on page 589 of THE ENGINEER (October 25), which incidently is the same as that developed by Captain Morris in his book *The Escalator Method in Engineering Vibration Problems* (equation 18, page 92), can be reduced to :

$$\Omega^2=\frac{EI}{mc^3}\left\{\left(6-\frac{2c^3}{k^3}\right)\pm\sqrt{\left(6-\frac{2c^3}{k^3}\right)^2+\frac{12c^3}{k^3}}\right\}$$

where

$$k^3=\frac{I_d}{m}$$

if the conditions for a cantilever are substituted, i.e.

$$y_{11}=c^3/3EI$$
$$z_{11}=c^2/2EI$$
$$\phi_{11}=c/EI$$

This is exactly the same formula Dunkerley obtained (formula B, page 304), which again shows the remarkable accuracy of Dunkerley's work.

J. B. WILCOX
Nottingham and District Technical College,
November 23, 1957.

Book Reviews

Business Charts. By T. G. ROSE, M.I.Mech.E. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, London, W.C.2. Price 21s.

IN these days it is hardly necessary to stress the value of charts in any business, indeed, two major wars probably did more than anything else to prove how essential they were to show at a glance how manufacture was progressing. Most managers of engineering works are ready to produce charts to show how they keep an eye on production, and at the same time ensure that their staff appreciates the position. It must, however, be confessed that on examining such charts it is obvious that often they are misleading, and are not revealing nearly as much as might have been the case, and this is where the book before us will prove of service to manager and student alike. During the war the simple bar chart was very useful in clearly showing the rate of production of ammunition, &c., but some firms engaged on this work made the mistake of not starting from zero and so, quite unintentionally, leading to false impressions. For example, if 2000 of an article were produced in one week and 3000 the next, the chart starting from zero would indicate an increase of 50 per cent whereas if 1000 had been taken as the zero line a quick glance at the chart would suggest that output had been doubled.

The author definitely states that his book is intended to give the minimum requirements of a business man rather than to meet the advanced ideas of the expert. He has been wise in this decision for the book is now admirably suited to the needs of those who, realising the value of setting out statistics in a graphical manner, are very hazy as to the best approach to the problem. The book begins with an explanation of the value of graphics (Chapter I), followed by descriptions of illustration charts, circle or pie charts, and symbolic charts, respectively (Chapters II to IV). The author then breaks away to give his rules for satisfactory chart making, which should be carefully studied by the beginner (Chapter V). He then returns to his main theme, devoting a chapter to each of the following : bar charts, amount-of-change line charts, a practical example of a line chart, the " Z " chart, the band chart, rate of change charts, and multiple chart sets (Chapters VI to XII). Finally, there are some general recommendations (Chapter XIII). An extensive bibliography concludes a useful work.

For general engineering work the pie chart is not suitable, whereas the bar chart is easy to read and admirably meets all the requirements of a demonstration of straightforward figures and facts. While the Gantt chart can show the daily schedule, the work actually done, and the cumulative work done, they sometimes prove baffling to the beginner on account of the fact that while equal divisions of space horizontally represent equal divisions of time, the same spaces also represent varying amounts of work performed. It is found, however, that very soon they can be understood, but though they serve a specific purpose, their field of service is somewhat limited. Mr. Rose appears to be strongly of opinion that the " Z " chart, so called because it invariably takes the form of that letter, " for the manager who wishes to maintain control over the results of his business, provides a form of graphical presentation of the facts which is far superior to any other type of chart." The great advantage of this chart is that it shows the three important figures of the current, the cumulative, and the moving annual total results, thereby giving the manager a continuous picture of his company's performance.

The author rightly points out that the best teacher of the more complicated charts is experience, and certainly some of the rate-of-change and multiple charts which seem to be difficult to appreciate initially, with use become understandable and of considerable value. We fully agree that it is desirable to have a standard size of chart, and that the data from which such chart has been prepared should be shown on the chart. Mr. Rose suggests that pencils should be used rather than ink, and crayons instead of paint, but if this is wise in the case of charts of permanent value, we are somewhat doubtful. To allocate a definite time for the careful study of the charts, without fear of interruption, is a good suggestion.

Nearly three thousand years ago the wise King Solomon declared that " of making many books there is no end " and certainly a similar statement might be made as to charts, there being always a great temptation to chart all statistics, and accordingly managers should be alive to ensure that only such charts should be prepared which are likely to be really useful. Sir Graham Cunningham, in his foreword, says that " a manager who has to run his business without accurate information and without the information contained in charts is like the surgeon trying to perform an operation without any hands," for by means of some of the charts shown in this book not only can he see what has happened in the past, but is able also to form an idea as to where his business is likely to go in the future. We are in full agreement with this and, accordingly, can recommend *Business Charts* to managers and other executives.

Coke Burning Appliances. The Gas Council, 1, Grosvenor Place, London, W.1. Price 15s.

THIS is the fifth edition of the handbook of approved solid fuel burning appliances prepared by the coke department of the Gas Council; it is designed to meet the needs of all concerned with the application of the Clean Air Act. Details are given of some 300 appliances which have passed performance and/or dimensional and constructional standards. The laboratory tests on the appliances have been supplemented by service experience under actual operating conditions to ensure that they can be relied upon to fulfil their purpose with complete satisfaction. As new appliances are developed and approved, data sheets will be issued for binding in the book. The approved appliances of some thirty-one manufacturers are listed in five main sections in the book—open fires, heating stoves, domestic boilers, small central heating boilers, and cookers. The basic construction of each appliance is given briefly with its specified capacity or output, and a drawing with the principal dimensions.

Book of Reference

Garcke's Manual of Electricity Supply, 1956–57. The Electrical Press, Ltd., 19–20, Noel Street, London, W.1. Price 77s. 6d.—The 54th edition, 1956–57, of this manual follows the pattern of its predecessors. In the first main section of the book there is a general survey of the industry, including a statistical review of progress based on the annual reports of the electricity authorities in England and Wales, and the North and South of Scotland districts ; nuclear power development and the activities of the U.K. Atomic Energy Authority are dealt with in this survey. There follows a section on the Central Electricity Authority and its divisional organisation, with an alphabetical list of generating stations and a series of tables giving comparative operational information about these stations. The next section deals with the area boards and then there is a section on the electricity authorities in Scotland, Ireland, the Isle of Man and the Channel Islands. A separate section is devoted to the companies manufacturing electrical plant and allied products. Finally the book contains a directory of " executive personnel."

Books Received

Work Sampling. Second edition. By Ralph M. Barnes. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 64s.

Brittle Behaviour of Engineering Structures. By A. R. Parker. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 28s.

Directory of Railway Officials and Yearbook, 1957-1958. Tothill Press, Ltd., 33, Tothill Street, Westminster, London, S.W.1. Price 40s.

Analysis of Indeterminate Structures. By J. C. Grassie. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 50s.

Engineering Properties and Applications of Plastics. By Gilbert Ford Kinney. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 54s.

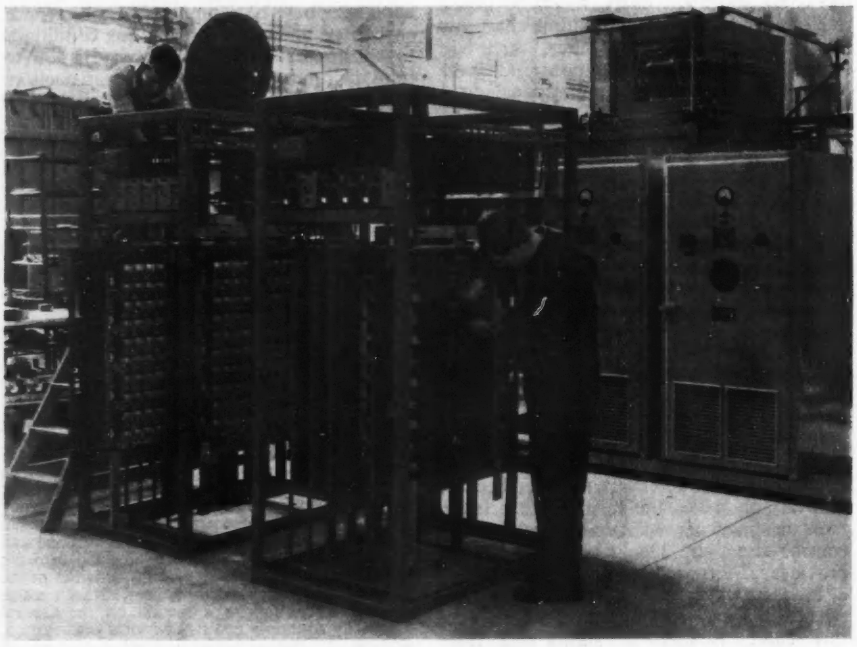
Thermodynamics of Fluid Flow. By Newman A. Hall. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 32s. 6d.

Weight Estimator's Data Book. By E. Molloy and M. L. Hall. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 15s.

Transformer Factory

The new Metropolitan-Vickers transformer factory at Wythenshawe, which was opened by H.R.H. the Duke of Edinburgh recently, is part of a reorganisation scheme started by the company in 1953. This plan envisaged a 50 per cent increase in the firm's capacity for building generating plant and heavy electrical machinery. Part of this increase came from space made free by moving the transformer department to Wythenshawe, where there was ample room for expansion and an adequate supply of labour.

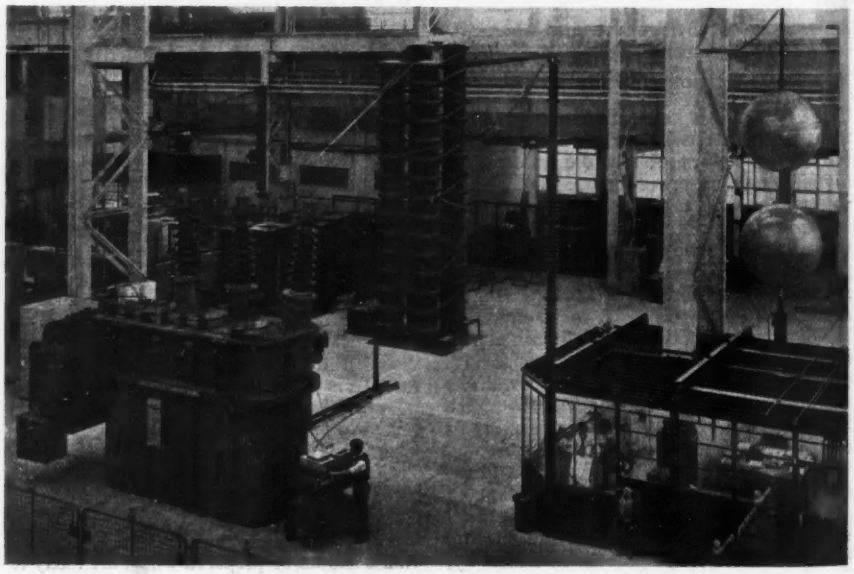
The part of the building shown here is the office block, with the canteen in the background (right). The works which is concealed by the office block in this photograph covers 28 acres of a 40 acre site leased from Manchester Corporation. Space is available for doubling the size of the factory and offices, leaving room for additions to the company's research establishment, including laboratories for nuclear metallurgy and extra high voltage testing.



With its cranes of 240 tons capacity the factory is designed for the construction of equipments consisting of (for example) a group of three single-phase units having a combined rating of 600MVA at 500kV. An item of interest in the core plate preparation bay is the batch type annealing plant which is used for the stress relief of core plates made of cold-rolled steel; cracked ammonia is used to give an inert atmosphere in this annealing process. For the subsequent enamelling of the core plates there are two varnishing plants, through which plates are fed on continuous conveyors. The cores are made from hot-rolled steel or cold-rolled, grain-oriented steel, but the latter material is being used increasingly as supplies improve. In the coil winding department the winding machines required for the highest transformer ratings and voltages were designed and made in the company's works. Metal formers are used to ensure dimensional accuracy which is needed in a coil if it is to withstand short-circuit stresses. The equipment at present being manufactured includes the core and windings of a 120MVA, 275/132kV, three phase, ON/OFB cooled auto-transformer for the C.E.B. On-load tap changers and instrument transformers are also made in the new factory. 11kV current transformers with cast resin insulation are now in regular production. For the output stages of magnetic amplifiers flux-resetting transductors are growing in popularity and the company makes both toroidal and spool transductors for use in both open and closed-loop servo systems.

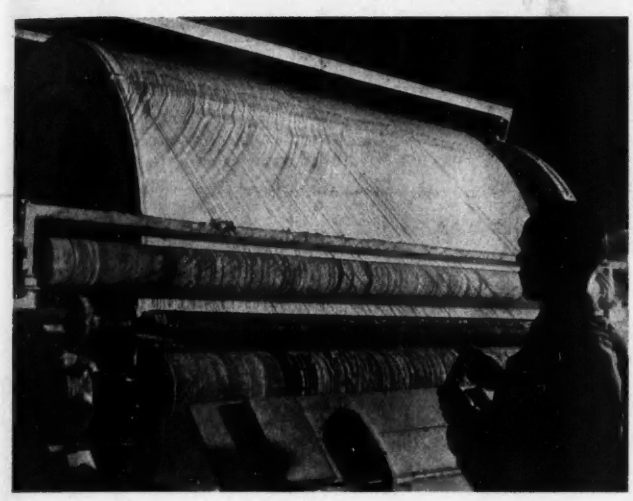
Power rectifiers are also made at Wythenshawe and the production includes glass bulb and steel tank equipments as well as semi-conductor rectifiers. Our second illustration shows 500kW, 230V, d.c. germanium power rectifier cubicles being assembled in the foreground; at the back are two glass bulk mercury arc rectifier cubicles. To reduce handling, the electrically heated ovens and baking plant are housed in the same bay, together with the equipment for shot blasting, atomic hydrogen welding, high vacuum pumping and leak detection.

One end of the factory is devoted almost entirely to the test departments, the layout being such that work in progress and work for despatch can be handled without being carried over the test area. Power for testing is taken from a separate substation containing eleven motor generator sets with capacities up to 30MVA; these machines can be remote-controlled from the test area. The test equipment shown in our third illustration includes a 2,500,000V, fifteen-step impulse generator which has a discharge energy of 67,000 joules. Impulse voltage measurement is by a 2m sphere gap and potential divider. Other interesting items of plant in the test area are 650kV and 750kV single-phase, 500kVA test transformers which are used mainly for transformer insulation tests and withstand tests

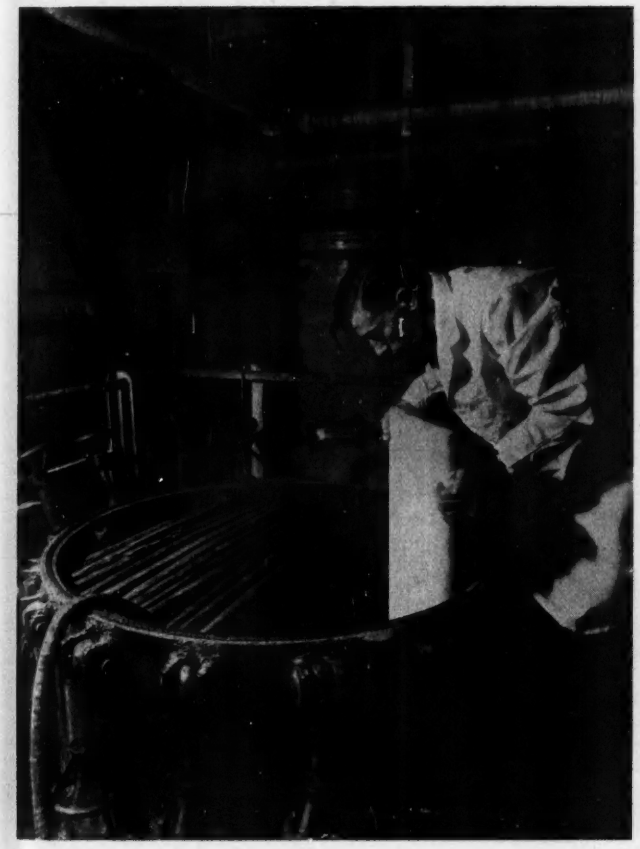


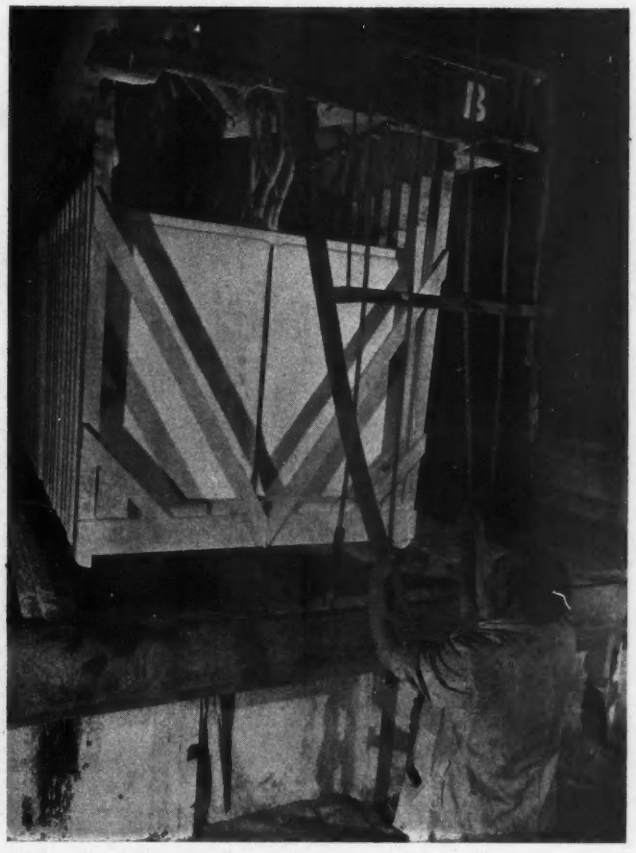
"Terylene" Filters

The manufacturing techniques employed by the British Titan Products Company, Ltd., for the production of titanium oxide pigments involve a number of filtering operations which are carried out under acid conditions at elevated temperatures. Constant search is maintained for more efficient materials and so reduce overall operating costs. Investigations have been carried out on filter fabrics made from various textile fibres and results showed that "Terylene," manufactured by Imperial Chemical Industries, Ltd., possessed the necessary physical and chemical properties as required by operational conditions. These properties include high strength, a high measure of resistance to mineral and organic acids, excellent resistance to heat and abrasion, and good resistance to flexing. The accompanying photographs show various filters in operation at the plant, and the illustration to the right shows a knife discharge rotary filter engaged in filtering a suspension of ferrous sulphate monohydrate, with 50 per cent sulphuric acid present, at a temperature of 55 deg. Cent. The filter has just commenced a new run and the



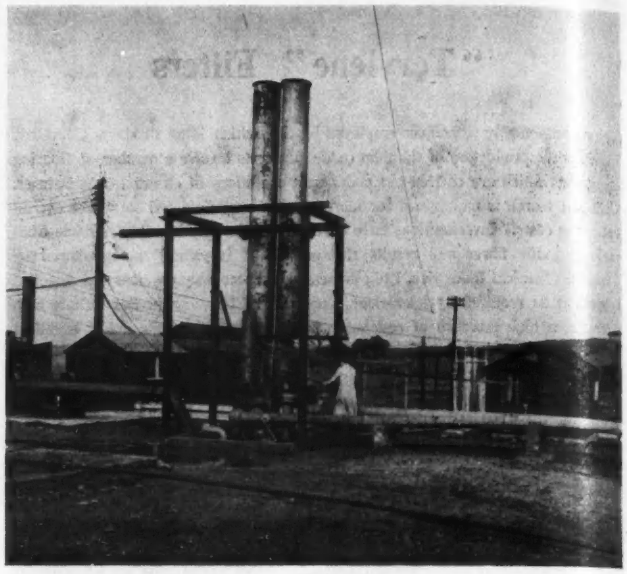
filter cake can be clearly seen forming on the filter fabric covering the drum. Here the acid resistance of the material gives it a longer life. A rotary string discharge filter is shown on the left, in which it is the duty of the discharge strings to lead the filter cake off the machine. These strings are braided "Terylene" cords which, by reason of their acid and abrasion resistance, have a longer life than previous materials. To assist in the filtration it is usual to place a coarse hessian fabric beneath the filter fabric to form an air space, and in this filter the hessian has been replaced with a "Terylene" brattice netting. In the illustration shown below and to the left a "Terylene" clotted plate in a Niagara filter is being inspected, while the photograph reproduced to the right shows the filter leaves of a Moore suspended leaf filter being raised. In this filter titanium oxide is washed and filtered at 50 deg. Cent. from a dilute sulphuric acid suspension and, apart from a lower initial cost, the fabric does not shrink and can also be washed more easily at high temperatures. The hoist control ropes and all other ropes in the plant are now of 100 per cent "Terylene," which, because of the acid conditions obtaining, have a much longer life than the original natural fibre ropes and provide an additional factor of safety. The material is also used for chemical discharge chutes and protective clothing, such as overalls and spun staple boiler suits





Underground Gasification at Newman Spinney

A visit was recently made to Newman Spinney to see some of the experimental work now in progress on the underground gasification of coal, and the projected pilot plant which will use the gas in a 5MW power station. The top of the first experimental shaft used in these trials, with the gas stacks and instrument hut, can be seen in our first illustration.



IN previous articles on the developments in underground gasification of coal in this country* particulars have been given of the progress at Newman Spinney, where the experimental programme was taken over from the Ministry of Fuel and Power by the National Coal Board in July, 1956, and in March this year placed under contract to Humphreys and Glasgow, Ltd. Under this contract the firm has been made responsible for the construction of a pilot scale gasification plant up to the gas inlet to a power station of the Central Electricity Authority. It will also carry out any further experimental and development work that may be required and prepare designs for a 60MW commercial scale gasification plant.

Experimental work is at present being concentrated at Newman Spinney and a further fifty acres have been acquired for the first five arrays of the pilot-scale plant. Work has already started on the pilot plant, which is due to be producing gas by December, 1958, and during a recent visit to the site we were shown some of the extensive experimental and development work in hand, so that the most up-to-date information can be used in the design of the pilot plant. The general layout of the experimental site with the shafts, galleries and bore-hole arrays can be seen in the plan we reproduce.

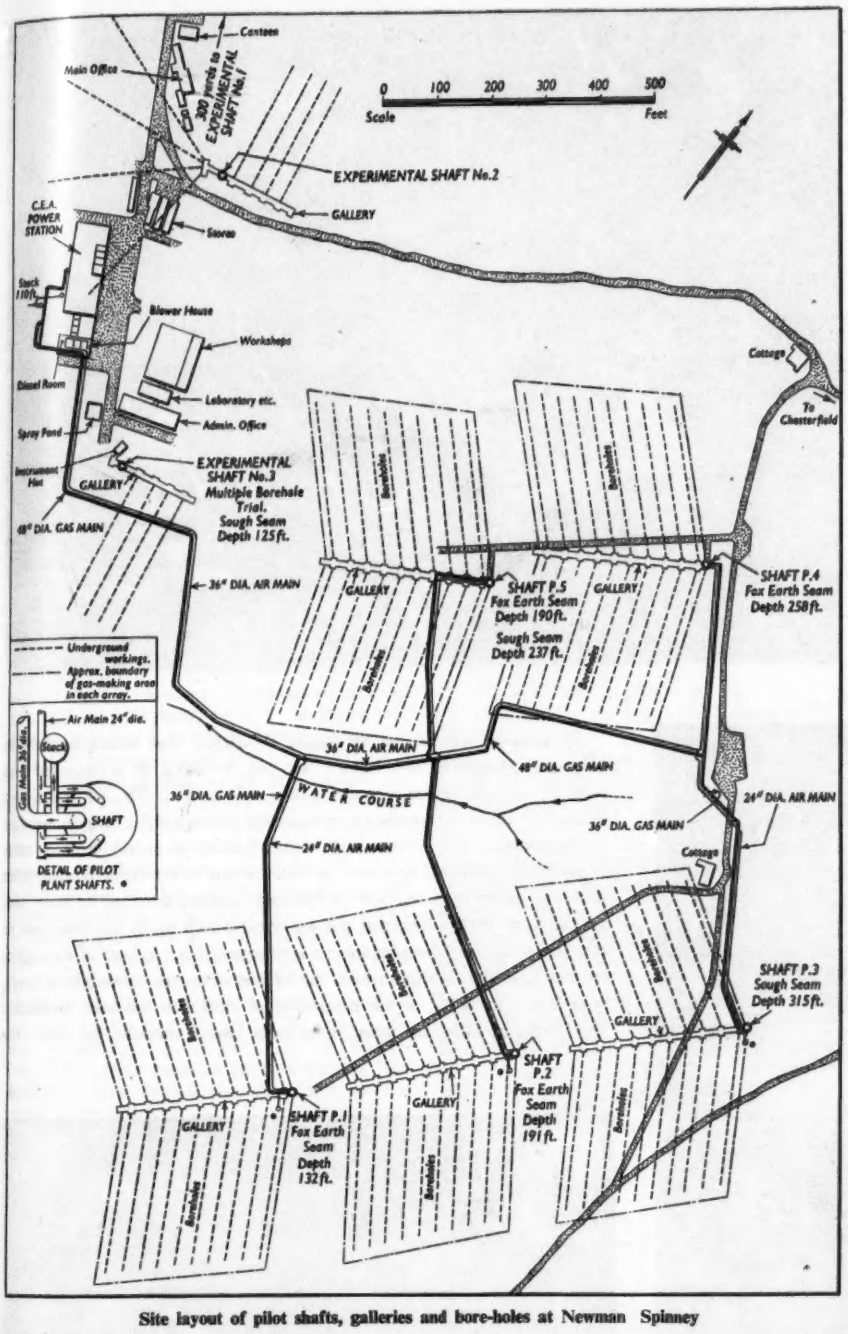
The pilot plant is being designed on the basis of the blind bore-hole technique which has already been described in these pages. Briefly the method consists of drilling horizontal bore-holes in the seam of coal and inserting an air pipe along each bore-hole. The coal is ignited at the blind end of the bore-holes and air is blown into the resulting reaction zone. Hot gases pass back along the bore-hole in the annulus between the pipe and the bore and transfer much of their sensible heat to the ingoing air in the pipe. So far all experiments have been conducted with single bore-holes, the gas being piped from the exit of these bore-holes to the surface.

Final preparations are now being made for the first multiple bore-hole experiment which has been prepared in one of the shafts (No. 3) on the experimental site. For this experiment the 315ft deep Sough seam is being used and four bore-holes, each 250ft by 12½in bore, have been prepared. This gallery with the bore-holes along the right-hand side can be seen in the accompanying illustration. The 4in diameter air pipes to be used will be made up of short lengths of high chrome cast iron with screwed couplings, having an improved form of joint which has been developed. The inbye 70ft—the tip or forward end—of each air pipe is protected by an additional refractory piping to enable it to withstand the very high radiant temperatures to which the air pipe is exposed in the early stages of the reaction. In previous experiments the gas has been taken directly from the end of the bore-hole but in this experiment, and for the first time, the gallery and shaft will be used to conduct the gas. Water sprays, situated in the shaft and the gallery, will cool the gas to 35 deg. Cent. by the time it reaches the shaft top. It will thus be possible to leave the gallery end of the air pipes free to expand and so reduce the stresses which were imposed on the pipe in other single bore-hole experiments and could result in failure before a section was completely gasified. This experiment is designed to give information on the behaviour of multiple bore-holes, particularly on the problems of controlling air flow to individual bore-holes from a common manifold. New kinds of air governors and various emergency bore-hole closure devices will be tested.

For a single blind bore-hole experiment, at present running in one of the shafts (No. 1), the bore-hole is 178ft long and it has a 2¾in bore high chrome iron pipe fitted with its inbye 70ft protected by refractory pipes. This trial was ignited on July 2, 1957, and was primarily designed as a test of this high chrome iron as a suitable air pipe material. A severe leak developed in the air pipe on November 4, and this experiment is being terminated. As in all such experiments, however, the opportunity has been taken to obtain as much additional information as possible and a pattern of vertical bore-holes has been prepared down to seam level through which readings of temperatures and pressure, together with gas samples, can be

*June 27, 1952; April 20, 1956; November 1, 1957.

Gallery being prepared for multiple bore-hole trial. The bore-holes can be seen on the right with the air supply tubes projecting



Site layout of pilot shafts, galleries and bore-holes at Newman Spinney

obtained with a view to establishing the spread of the reaction underground and the reactions taking place at particular points.

In another shaft (No. 2) a single blind bore-hole experiment with a mild steel air tube protected throughout with refractory piping was concluded earlier this year and the air pipe and other materials recovered from this experiment provided valuable information on the effects of the high temperatures on the materials used. Following the extinction of this experiment, vertical drilling was carried out from the surface to establish the shape of the reaction zone obtained, and this drilling showed a very regular pattern with an overall width of between 27ft and 29ft. It further showed that the experiment which had already run for some five months could probably have carried on for as long again. Horizontal drilling is now going on in another shaft (No. 2) in preparation for a further series of experiments with different kinds of air tube materials.

An important part of these initial experiments is to establish a suitable air pipe material which, while capable of withstanding the high temperatures obtained in the reaction, will not be so expensive as to affect adversely the cost of the gas produced. As the air pipes have to be taken down the shafts and galleries and then inserted in the bore-holes, which are approximately at right angles to the galleries, they have to be handled in fairly short lengths and be capable of being jointed underground to give an air-tight joint which will withstand the temperature conditions. Preliminary tests on suitable pipe and jointing materials and methods are also being carried out on the surface in what are referred to as "Trench Tests." In these a simulated coal bed containing about 20 tons of coal is prepared with a dummy bore-hole in which lengths of air pipe can be tested under conditions approximating to the conditions obtained in an underground bore-hole. The coal contained in such a bed enables gasification to be carried out for four or five days, during which time a comprehensive set of readings of temperatures at various points throughout the period of the trials are taken. At the conclusion of the experiment the lid of the bed can be removed and the remaining air pipe examined.

In addition to these major experiments a continuing programme of minor experimental work is carried on, particularly in connection with such problems as the ignition of the coal, air governors, and air pipe jointing methods.

Pilot Plant for Power Generation

The pilot plant is being designed to produce enough gas to generate approximately 5MW of electricity and the gas will be burned in the power-house boilers for the generation of electricity by a conventional steam turbine and alternator. A survey of the available coal measures at Newman Spinney was carried out earlier this year by the Opencast Executive, and on the basis of this survey the positions of the first five pilot plant arrays have been fixed, preliminary surface works have been undertaken and sinking of the first shafts has commenced.

Each of the pilot plant arrays to be seen on the plan we reproduce will have a concrete-lined shaft, 8ft in diameter, going down to the selected coal seam. From this shaft a gallery 100 yards long will be driven into the coal seam and from either side of this gallery bore-holes 100 yards long will be drilled in the coal seam at 10-yard intervals. Thus there will be ten bore-holes on each side of the gallery embracing an area of approximately 20,000 square yards of coal seam. Air will be conducted to the far end of each bore-hole by air tubes in the bore-hole, which are fed via blast mains running down the shafts and gallery with air from a central blowing plant adjacent to the power station. Gas returning along the bore-holes will be cooled by water spraying in the gallery and shaft, the top of the shaft being capped with a gas offtake connected by surface mains to the power station boiler-house. The sprays of cooling water will also serve to scrub the gas and the contaminated water will flow into sumps at the end of each gallery, whence it will be pumped back to a surface storage tank for recirculation.

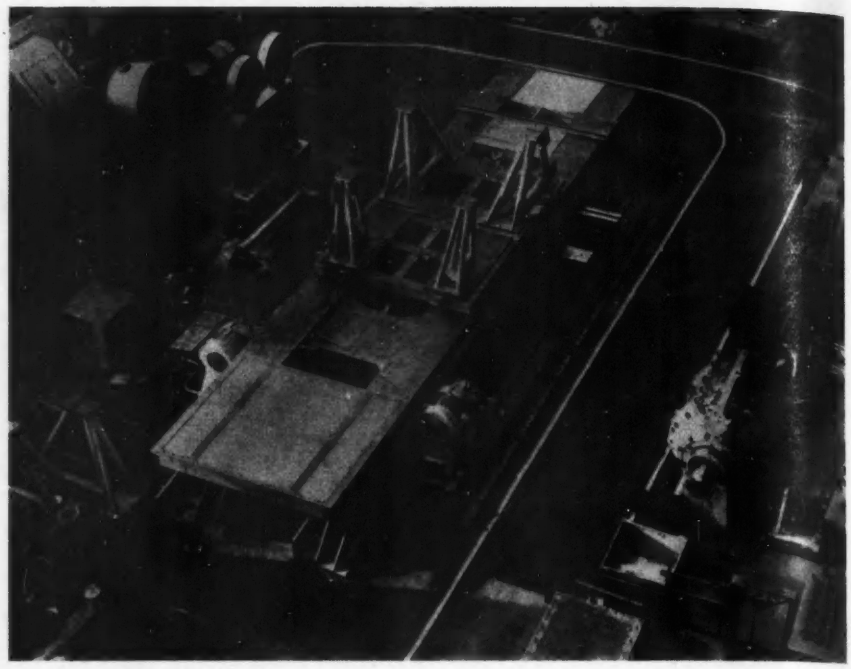
In order to supply the gas requirements of the power station two such arrays will be gasified together, and it is estimated that each array will have a life of about nine months. While two arrays are being gasified other arrays will be in course of preparation, so that they may be brought into use as previous arrays reach the end of their useful life.

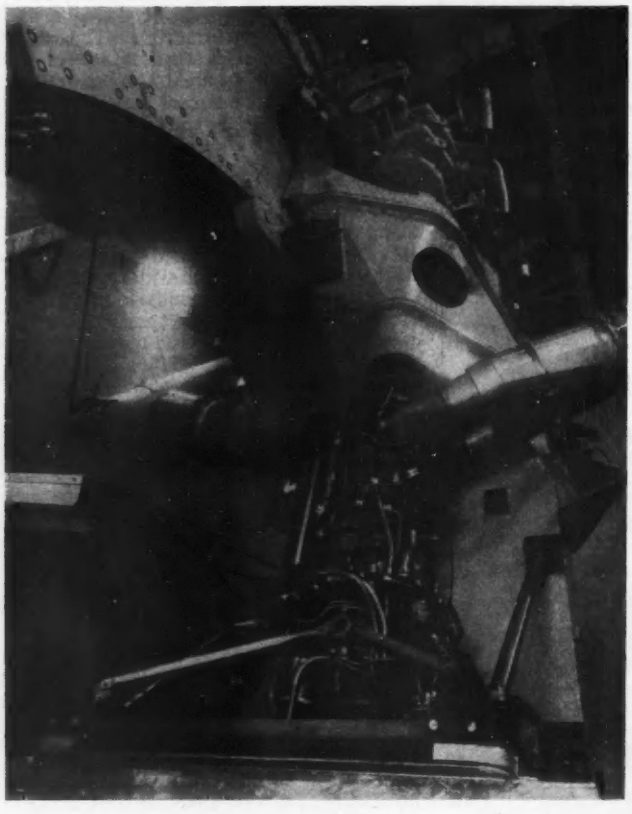
The pilot plant is being laid out to give much experimental information and will therefore be instrumented on a far wider scale than would be necessary for a full-scale commercial plant. Furthermore, it is pointed out that, with a full-scale plant, longer galleries and bore-holes would be used with more widely spaced shafts, so that the disturbance to the countryside by a commercial plant would be very much less than in the case of the present pilot plant.

A complementary and important side of these experiments is the development of techniques for directional drilling of bore-holes to follow seams of coal, and this work is being carried out under particularly suitable conditions in a disused part of the nearby Oxcroft colliery. At this colliery trials are being carried out using a Boyle's experimental rig and a Nüsse and Graefer rig. To date, some excellent results have been achieved in drilling long bore-holes, reaming them out to 12in diameter, and in directional control following the course of a seam.

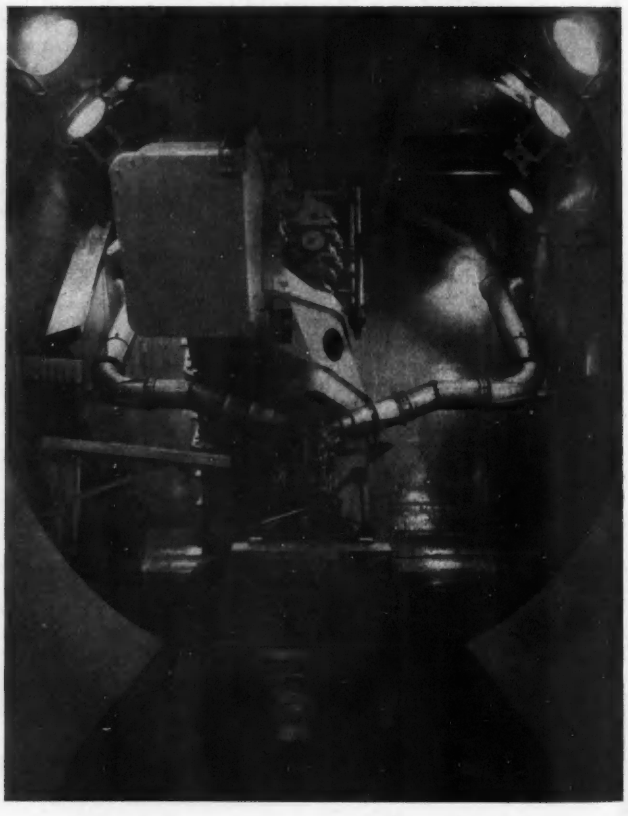
Aero-Engine Test Beds

The illustration alongside shows the calibration in the works of Heenan and Froude, Ltd., Worcester, of a thrust cradle required to measure the thrust of jet engines with extreme accuracy; the deadweights used can be seen in the foreground. To minimise friction, the moving part of the cradle has been mounted on three self-aligning bearings jacked with oil. Despite the fact that the bed-plate was laid down as accurately horizontal as possible, it was found that the moving parts moved in a few seconds to one end of their travel, and this is attributed to an inclination of 1 in 24,000. In fact, the moving parts, which weigh 7 tons, can be set in motion by a force of 8 oz. The cradle has now been delivered to the National Gas Turbine Establishment.





The universal test bed for the Napier "Gazelle" free turbine appears in illustrations alongside and below: the cell in which it is mounted was originally used for testing propeller engines on a hanger. The bed is intended to allow the engine to be tested in any of the attitudes in which it may be installed in a helicopter: in the Westland "Wessex" it will be heavily inclined, while in the Bristol 192 it will be almost vertical. Instead of the engine turning about pivots, as in the Alvis test bed for helicopter engines, described on page 264, February, 15, 1957, a large and stiff arc provided with tracks has been built to carry the engine and dynamometer: it is so arranged that one end of the engine, the intake, suffers no displacement, and by this means the connection of leads, controls and so forth, for use irrespective of inclination has been facilitated. The illustration shows the main engine speed control emerging just under the window of the control room, dropping down to a bell crank opposite the centre of the arc, and running across to the engine. The instrument tappings are carried by flexible hoses confined in the conduit on the opposite side of the engine. The exhaust ducts are carried partly by the engine bearer and partly by a pair of arms swinging about the same axis: telescopic sections lead away to the air outlet.



The close-up view above shows that the engine is mounted on a platform supported from the main beam: the air supply is ducted in under the floor. There is at present no drive shaft installed, but in use the output would be carried up to a Heenan and Froude water brake mounted close against the supporting arc. The engine shown is instrumented for, very largely, the measurement of pressure at various stages in the turbine.

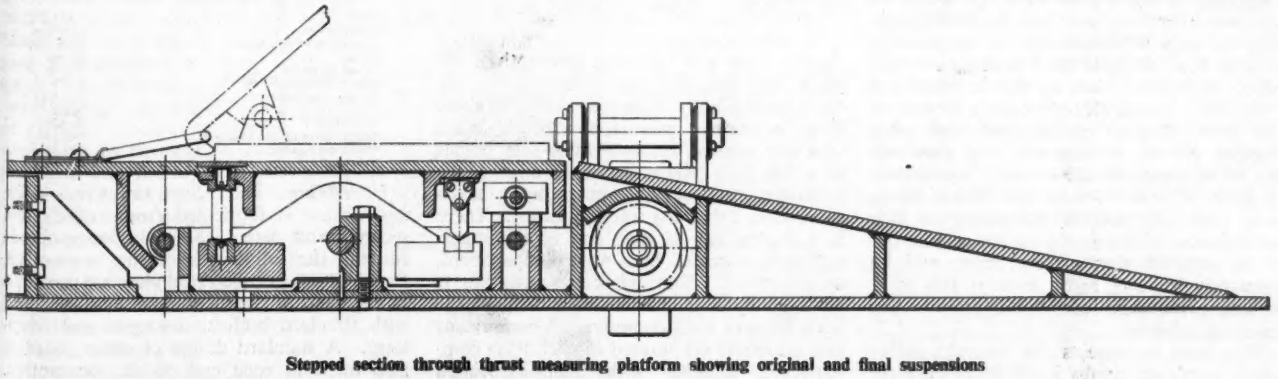
Aero-Engine Performance Measurement

Contemporary high-performance aircraft are comparatively sensitive, particularly in terms of range, to engine performance. Thus high-grade dynamometers for development and acceptance testing, such as are shown on the facing page, are being supplemented by equipment to assess installed thrust.

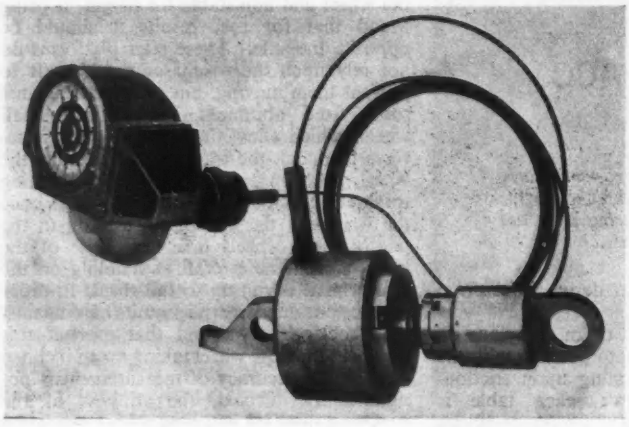
It has been a widely accepted practice to test an aircraft power plant when first built or overhauled and to assume that during its service life its output can be inferred from fairly easily measured quantities such as shaft speed, temperature or torque. In an attempt to gain a closer insight into the performance of engines during their installed life, British Overseas Airways Corporation has developed thrust measuring equipments. These are derived from the weight measuring units that had already been designed by Mr. F. S. Saunders, of the Corporation staff, and placed in production by Alltools, Ltd., Transport Avenue, Brentford, Middlesex. The principle is simple, the applied force being supported by a fluid and the pressure in the fluid observed; problems of sealing and stiction are eliminated by a Neoprene diaphragm separating the liquid from the piston. The measuring device consists of a Bourdon tube of roughly 180 deg. extent and a linkage giving extremely high magnification; the fluid pressure at full load is usually about 5800 lb per square inch. For the smaller weighing cells, the indicator is in unit with the capsule, and a presentation with three concentric needles moving over scales of units, hundreds and thousands is used. Such an indicator would resemble that seen in the illustration overleaf of the airborne equipment, the load cell being attached on the nearer side in place of the capillary junction; noteworthy is the frangible translucent bottom cover enclosing the Bourdon tube, which shatters if the instrument is treated harshly enough to impair its accuracy, and also serves as a suggestion that the device be laid down flat on its back, thus unloading the pivots in the amplifying linkage. The 50,000 lb weighing cell, however, has remote indication, a flexible capillary being stowed on a spring-loaded reel in the case containing the indicator. This larger instrument has a two-needle display; a vibrator is included to prevent a systematic error due to a human hand tapping it. A capillary which is perfectly docile has been obtained by using a stainless steel tube wound with a wire sheath; the surface finish of the wire is such as to provide damping for the spring action of the core. All these instruments are individually calibrated, each having its own chart to derive force from scale reading.

To measure the thrust of an aeroplane on the ground, it is towed into position with the main landing wheels resting upon frictionlessly suspended tables; each table is restrained longitudinally by a load cell as described above connected to a remote indicator. Early designs had the table supported upon knife edges, but the change in height as the blades departed from the vertical made setting-up critical; one such support can be seen in our diagram, which shows a platform for a Pyrene folding chock. The left-hand, or aft, support in the diagram shows the current pattern, in which rollers take the place of knife edges. Rollers and tracks are hardened, and pegs in the rollers entering holes in the track keep the axes of the rollers in the transverse plane. These supports are in fact used in a different platform with a fixed chock, and the load cell is not under the platform, but in front of the wheel and adjustable for height, it being found that for best results it should be opposite the axle. These later platforms do not rely upon the weight of the aircraft to prevent them moving, but are placed against some fixed abutment. There are small wheels which allow them to be moved sideways to match the track of the aircraft, the wheels being sprung by a coil spring running transversely under the platform so that once the weight of the machine comes on to the platform the wheels take very little of the load. When the aircraft is standing on the platforms it is run up to full thrust in order to force both undercarriage units hard against the chock; it is found that even if this results in the nose wheel taking up an inclined attitude the accuracy of measurement is not significantly affected, the stiffness of the structure, nose leg and nose wheel tyre being inadequate to restrain the main wheels. The test is carried out with the wheel brakes released. The discrepancy between the thrust line and the horizontal is found to be immaterial in the case of an aircraft with a nose wheel landing gear. Another interesting finding is that the constraint against yaw afforded by the chocks is so great that an engine outboard of the undercarriage develops thrust on both chocks; if this should not be the case when engines far outboard were tested, clearly inboard engines could be kept running throughout and the desired thrust obtained by subtraction. The photograph reproduced here shows a Hawker "Hunter" 6 in position on the chocks; the

A Hawker "Hunter 6" prepared for thrust measurement; the nose wheel is resting on greased steel plates



Stepped section through thrust measuring platform showing original and final suspensions



One of the two force measurement units of the Fairey "Delta 2"

nose wheel is resting on the upper of a pair of steel plates lapped together and lubricated, and it was found that the aircraft could easily be moved on the platforms by hand. The platforms have also been used with the English Electric "Canberra" and a fighter of such high thrust-weight ratio as the Vickers-Supermarine "Swift" with reheat. Calibration of the platforms by the National Physical Laboratory showed a difference between thrust increasing and decreasing of the order of 4 lb only, and an accuracy within $\pm 0 \cdot 3$ per cent. The use of such devices is expected to provide very cheaply at least some information about the influence of intake systems, propelling nozzles, and auxiliary bleeds.

Another application for these hydrostatic transducers is as thrustmeters in aircraft. When a power unit is installed, even coarse assessment of its performance is rendered slow by the influence of constant speed units, automatic fuel controls, and other monitors. Even accurate analysis by the flight engineer depends upon inference from indirect measurements applied to the measured performance of the new engine, and may therefore not be reliable on an engine part way through its life. Thus it may prove to be of value to check the actual thrust in the conditions of ambient pressure and temperature prevailing before taking off. A more difficult but interesting possibility is the continuous measurement of thrust in flight; it is known that modern aircraft, in which the fuel weight is a very large proportion of the take-off weight, demand sensitive flight planning and accurate cruise control, and operation of the aircraft may be made easier by observation of the thrust developed. It is realised by British Overseas Airways Corporation that, since turbine life is a function of speeds and temperatures rather than mass flow, the scatter of engine lives would probaby be increased if the engine were controlled by output rather than, as at present, shaft speed, but the gain in consistency of operation is expected to be justified. A comparatively slow jet airliner, such as the de Havilland "Comet," is naturally particularly dependent on meteorological environment and other factors difficult to measure, and therefore B.O.A.C. intend to incorporate thrustmeters in their "Comet" 4 machines. The readings are obviously subject to correction for acceleration forces acting on the engine, but it is expected that no correction will be necessary in level flight, even if this is at constant indicated air speed rather than constant incidence.

The need to process the readings extensively to obtain results is, of course, acceptable in a research aircraft, and one of the Fairey "Delta 2" machines has been equipped for continuous indication of the reaction on the engine mountings. The main trunnion on each side of the engine is carried by a bell crank, which, in the original design, passed the drag forces into a solid link with self-aligning end fittings. The links have been replaced by a pair of 14,000 lb load cells; the cylinder piston assembly is regarded as a ball joint, the cylinder being rigidly mounted, as can be seen in our illustration, while the opposite end of the unit incorporates the Hoffman roller joint standard at this point. The two indicators are surveyed by the automatic observer and the thrust derived from these and other appropriate readings. These units differ in some ways from the ground-based equipment, particularly as very large changes of temperature are encountered. The piston and cylinder are of Nilo 36, the circumference of the piston being coated with Stellite, so that changes in the effective area are negligible. In all cases the working fluid is glycerine based and the amplifying linkage is compensated by bimetallic strips, so that accuracy is unimpaired at all temperatures at which calibration can be performed; the severest case is the high temperature reached after the engine is shut down and cooling air ceases to flow, and the transmitter will resist temperatures from −40 deg. to 100 deg. Cent. For ease of installation a coupling is provided in the capillary; each half consists of an accurately faced orifice with a Neoprene diaphragm stretched across it, and when the joint is made the two diaphragms are brought face to face. The joint is placed at the indicator end of the capillary so that volume changes in the line do not add to the diaphragm movement. Each meter with 15ft of capillary weighs $8\frac{1}{4}$ lb; the accuracy is ± 5 lb at maximum loading. The movement that must be allowed for in the engine mounting is 0·012in to 0·015in in the working range and 0·07in in the event of loss of fluid pressure. We are informed that the "F.D.2" installation has consistently given satisfactory and significant results.

3120 h.p. Electric Locomotive for Indian Railways

Twelve 3120 h.p., 111-ton C_0-C_0 electric locomotives are being supplied by the English Electric Company, Ltd., to Indian Railways for the 3000V electrification from Howrah to Moghalsarai. These locomotives, which are described here, are to be capable of handling express and slow passenger trains as well as freight trains.

EARLY in 1954 it was decided that Indian Railways should electrify at 3000V d.c. the suburban system in Calcutta and the main line from Howrah to Moghalsarai via the main and Grand Chord lines. The operating requirements specified a dual-purpose locomotive capable of handling express and slow passenger trains and also freight trains on these lines, with the exception of the heavily graded section Gaya to Asansol, where freight trains are not required to be handled.

The following table shows the specified balancing speeds of a single locomotive hauling the load specified on ascending gradients at 2900 line volts :—

Type of train	Ascending gradient	Estimated balancing speed, m.p.h.	Field connection
630 tons passenger...	Level	71·1	w.f.
630 tons passenger...	1 in 200	57·5	w.f.
630 tons passenger...	1 in 80	39·3	f.f.
825 tons parcels ...	Level	57·6	f.f.
825 tons parcels ...	1 in 200	44·5	f.f.
825 tons parcels ...	1 in 80	37·0	f.f.
2300 tons freight ...	Level	44·6	f.f.
2300 tons freight ...	1 in 400	38·2	f.f.

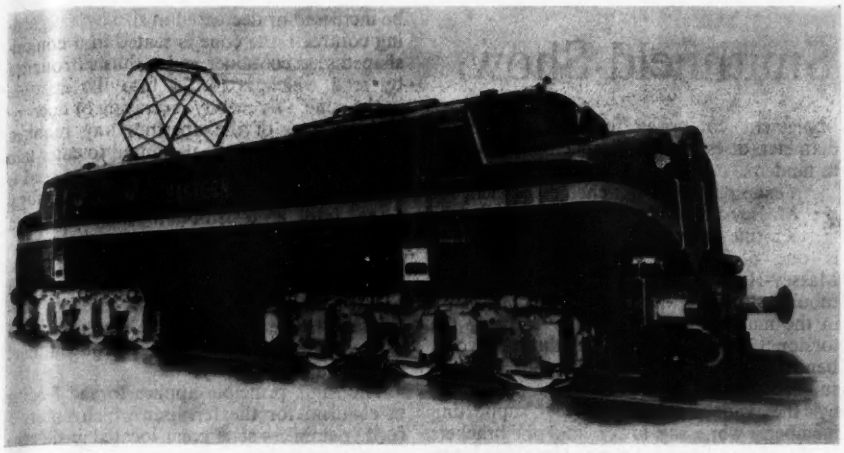
General Arrangement of Locomotive.— Twelve 3120 h.p., 111-ton locomotives are being supplied, for this electrification, by the English Electric Company, Ltd., Stafford. Each locomotive consists of a single superstructure carried on two three-axle bogies in which each axle is driven through single reduction resilient spur gears by a nose-suspended, axle-hung traction motor. There is a driving cab at each end of the superstructure protected by a nose compartment, as illustrated. Through communication is achieved by a central corridor through the main body of the locomotive. A compressor and exhauster are housed in each nose compartment, together with their associated contactors and resistances, entry to the compartment being gained by a central door. The driving position is at the left-hand side of the cab next to the master controller brake handles and driving instruments. The hand brake is near the assistant's position at the right-hand side of the cab. The high-tension control equipment is in two equipment frames in the main body compartment, together with the two main starting resistance frames and the two motor generator sets. Each high-tension frame forms a compartment with bulkheads, and the locomotive side and the access doors in the cab bulkheads are mechanically interlocked with the pantographs and main earthing switches. The whole layout of the locomotive is symmetrical to give lateral and longitudinal balance.

The main particulars of the locomotive are tabulated below :

Main Particulars of 3120 H.P., 3000V Electric Locomotive for Eastern Railway, India

Class	"EM/2"
Horsepower	3120 h.p.
Maximum service speed	70 m.p.h.
Gauge	5ft 6in
Wheel diameter	3ft 7in
Gear ratio (62/16)	3·875
Length over buffers	65ft 10in
Bogie centres	34ft
Axle centres	7ft 4½in
Height (pantograph lowered)	14ft 1in
Width over gauge	10ft 8in
Axle load	18½ tons

Underframe and Superstructure. — The underframe is fabricated from rolled steel sections and plates, the main longitudinals running the full length of the locomotive. Buffer beams of rolled steel plate are provided at each end of the locomotive and are fitted with standard buffers, drawgear and couplings. A standard design of cattle guard is also fitted at each end of the locomotive.



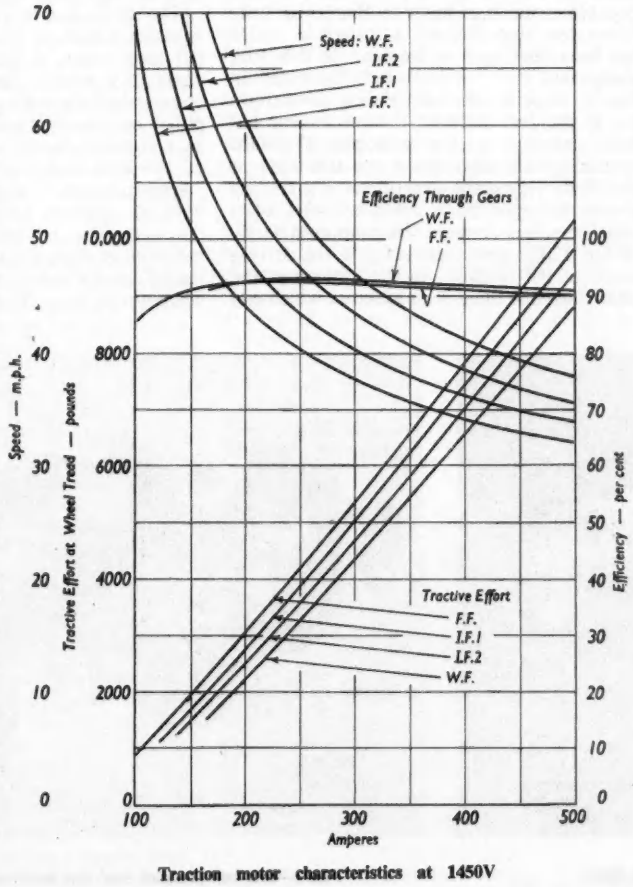
3000V d.c., 3120 h.p. locomotive for Eastern Railway, India

The superstructure framing is of rolled steel and pressed sections. It is divided into sections to facilitate construction, each of which is assembled on jigs for welding. All joints are seam welded and ground flush to provide a smooth and pleasing appearance. The roof over the main body compartment is sunk below normal roof level to house the pantograph and is in two removable sections. Special monsoon louvres are fitted in the locomotive sides to exclude rain water from the filters.

Bogie.—The underframe is carried on two slab frame bogies with swing link bolsters of a design previously used on English Electric locomotives in Brazil, Spain and India. The basis of each bogie is two robust side frames of rolled steel plate, flame cut and machined to profile, secured to fabricated steel transomes and headstocks by means of driving fit bolts. The superstructure is carried through the centre pivot on to an annular bearing surface on the fabricated double bolster. This bolster is supported on two fabricated spring plank assemblies through four groups of double elliptical leaf springs and the spring planks are suspended by long links from the transomes. Stops are provided on the side frames to limit the lateral movement of the bolster when under control of the bolster springs and swing links. Dual compensating beams are fitted between adjacent axleboxes and the vertical load is transmitted to each compensating beam through two sets of concentric coil springs located between the beam and the top of the side frame.

The wheels are built up from rolled steel disc centres with tyres secured by riveting. Each wheel is fitted with clasp brakes operated through compensated rigging, each wheel set of brake blocks being operated by an air cylinder mounted on the side frame. The axleboxes are of cast steel and are fitted with roller bearings. There are twelve sandboxes on each bogie, six operating for each direction of locomotive travel.

Electrical Equipment.—All the electrical equipment, with the exception of the traction motors, pantographs and lightning protection equipment, is mounted in the locomotive superstructure. Each of the six force-ventilated traction motors develops 520 h.p. at the one-hour rating and is insulated for the full line voltage. Three stages of field weakening are provided by a combination of field-tap and divert resistances. Each motor is attached to the bogie transome by a resilient nose suspension and is supported on the axle by journal bearings. The characteristics of the traction motor at 1450V to meet the operating requirements specified above are shown in the accompanying curves.



Traction motor characteristics at 1450V

The high tension control equipment is mounted on two frames which form compartments with the locomotive sides. The sub-division of equipment between the two frames is so arranged that when half of the traction power circuits is isolated, the equipment in one frame only controls the three motors on one bogie. Isolation switches are also provided to enable any one traction motor to be isolated, while the remaining motors can operate up to the series full-field connection; these isolating arrangements are peculiar to Indian Railway practice.

Two motor generator blower sets are provided. Each blower supplies cooling air to three traction motors on one bogie, and air is tapped off the main duct to ventilate the high tension frame and nose compartments. Each generator supplies a compressor and exhauster and the remaining low tension circuits—including the interior ventilating fan, low tension control circuits, battery charging circuits and speedometer equipment—can be supplied from either generator through a low tension changeover switch.

The alkaline battery for the control and lighting circuits is in a ventilated container in the body of the locomotive, just below the interior ventilating fan. Most of the low tension control equipment is in a frame next to No. 1 driver's cab with access from hinged doors in the cab and body. Protection of the low tension equipment is by miniature circuit breakers instead of fuses.

There are two pneumatically-operated lightweight pantographs and connections are taken to isolating switches in one of the high tension compartments. Each pantograph is connected to lightning protection equipment consisting of a lightning arrestor and capacitor. The pantographs embody double pans which are so balanced that they can follow irregularities in the overhead wire without movement of the main frame.

The main starting resistances are of expanded metal and are mounted in two separate compartments, one next to each high tension compartment. The resistances are naturally cooled by air drawn through the underframe and louvres in the locomotive side and expelled through cowls in the locomotive roof.

The brake system is of the air vacuum type, the services being provided by two Westinghouse DVC3 compressors and two Northey 180 RE exhausters. The system is arranged so that the straight air brakes on the locomotive are applied automatically through a vacuum/air proportional valve when a vacuum brake application is made on the train. A six-position selector switch is provided in the low tension frame to give a wide combination of running speeds on the two exhausters.

Operation.—The power circuits are arranged for series, series-parallel, and parallel connections of the six traction motors with shunt transition between groupings. These connections are controlled through a handwheel master controller which provides seventeen resistance notches in the series grouping, nine notches in the series parallel grouping, and six notches in the parallel grouping. The equipment is arranged to notch back in exactly the reverse sequence to that obtained when notching up.

NATIONAL BOAT SHOW.—The fourth National Boat Show will be opened at the Empire Hall, Olympia, London, on January 1, 1958, by Field-Marshal Viscount Montgomery, and it will remain open until January 11.

Machinery at the Smithfield Show

THIS week, the Smithfield Show and Agricultural Machinery Exhibition is being held at Earls Court. It opened on Monday morning and ends this (Friday) evening. It must be one of the oldest exhibitions to take place in London, for, apart from breaks during the two world wars, the "Smithfield" has been staged annually since the 1790s. From its very early days, it has included, in addition to exhibits of prime cattle, a display of farm machinery and implements. This latter display now occupies by far the greater part of the exhibition at Earls Court.

In our last issue we described some of the tractors which are exhibited, confining ourselves to tractors from British manufacturers which have been introduced in the last few weeks. This country's tractor production is now higher than it has ever been ; last year over 108,500 three- and four-wheeled farm tractors, as well as more than 3000 crawler tractors and 28,000 market garden tractors were turned out by British factories. The tractor export figures are likewise impressive. There were over 2000 crawler tractors exported last year, compared with four in 1938, and nearly 90,000 wheeled tractors compared with just under 6000 in 1938. It is obvious, of course, that the rapid growth in the tractor population has brought mechanised agriculture to its present high standard. Farm implements and machinery, for the most part, are now designed and produced to "match up" to the power and versatility of the various tractors available to farmers. Tillage implements, harvesting machinery, farmyard equipment and an increasing proportion of handling and transport equipment, all suited to certain tractor requirements, are prominent in the extensive display of machinery at the Smithfield Show.

Tillage Implements

"Power-matched" implements shown by Ransomes, Sims and Jefferies, Ltd., Ipswich, include those which are being produced for operation with the Fordson "Dexta" tractor. Among them there is a single furrow mounted plough which will work to a depth of 12in, and from 12in to 16in wide. There is also a two-furrow mounted disc plough, and a 7ft trailing disc harrow. This latter implement comprises four gangs of 20in diameter discs, with 6in spacings, arranged in tandem.

An example of the matched equipment for the Massey-Ferguson "65" tractor is the thirteen-tine tiller illustrated in Fig. 1. It is one of several implements shown by Massey-Harris-Ferguson, Ltd., Coventry. A tubular steel member has been incorporated in the main frame of the tiller to carry the torsional stresses incurred during work. Bending stresses to which the tool bars are subject during work are reduced, it is claimed, by the wide spacing of the supporting members, while the lower link pin brackets of the box sections withstand the offset loads imposed by the pins. The tines are spring-loaded so that they ride over obstructions, and they are capable of loosening and aerating soil to a depth of 9in.

Among the smaller tillage implements there is a self-propelled handlebar controlled rotary cultivator which is made by Wolseley Engineering, Ltd., Witton, Birmingham, 6. Its power is provided by a four-stroke, 75 c.c. petrol engine, developing 1 h.p. A pressed steel casing contains a double chain drive which actuates a power shaft emerging from the lower end of the casing. This shaft is fitted with spring clips by which the cultivating rotors are easily attached. The rotors have finger-shaped tines which dig—by a "stirring" action—to a depth of 10in. The operating width of the "Merry Widow," as the machine is called, is 12in.

Seed and fertiliser drills fall quite properly under the heading of tillage machinery. One of the new combined seed and fertiliser drills shown at Earls Court is a distinct departure from conventional practice. It is a precision drill which has been made by Bamfords, Ltd., Uttoxeter, and follows a principle which has been developed in Sweden. In this drill, designated the "SF13," and illustrated in Fig. 2, there is only one feeding mechanism for all the drill outlets ; this mechanism has been designed on the principle of a feed operating at a high speed yet still able to distribute very small quantities. The feeding device incorporates a stainless steel cone which revolves at speeds from approximately 300 to 1200 r.p.m., according to the driving speed of the tractor. In the bottom of the revolving cone there is an aperture which can be increased or decreased in size by a regulating control ; the cone is seated in a conical-shaped seed container and is thus surrounded by seed which is forced into the aperture in the cone. By merely increasing or decreasing the area of the aperture any required amount of seed can be permitted to enter into the revolving cone. After entry, the seed is evenly thrown out of the cone by centrifugal force into a distribution manifold with receiving channels from whence the seed is directed into the tubes leading to the drills. By having one feeding device running at a high speed the velocity of the seed is considerably increased, giving a real force feed as compared with that of a conventional drill relying on gravity.

The same principle applies to the feeding mechanism for the fertiliser which enters a further stainless steel cone located inside the seed cone. This also has an adjustable aperture and the material is fed by centrifugal force to the distribution manifold channels and then to the drill tubes as with the seed. The outlet ports in the manifold are double in design with the fertiliser outlet at the top and the seed outlet below it ; both can be fed into a single drill tube or into separate tubes if double manifolds are used. The seed ports, incidentally, can be blanked off by slides, which are fitted below the manifold outlets, thus enabling any selected number of seed drills to be employed. The amount of seed or fertiliser to be sown is controlled by the apertures in their respective inner cones and is regulated by means of a calibrated scale below the edge of the vee-belt drive pulley at the base. A mark on the pulley indicates the setting against this scale for seeds and a small finger underneath the scale shows the setting for fertilisers. There is an air duct between the seed and fertiliser cones so that when the drill is working the air flow through this duct acts as a blower to aid the feed of materials into the drill outlets.

The drive for the drill is taken from a sprocket bolted on to the outside of the rear left road wheel of the tractor and then by chain to a smaller sprocket which drives a countershaft through gearing. From a vee-pulley on this countershaft the drive is taken by a crossed vee-belt to a pulley on the base of the drill feed mechanism. The drill is "semi-mounted" and is suitable for use with all tractors with three-point linkage. An automatic cut-off disengages the feed mechanism when the coulters are lifted, and the lift raises the discs to give ample clearance when not drilling. The discs are held at work

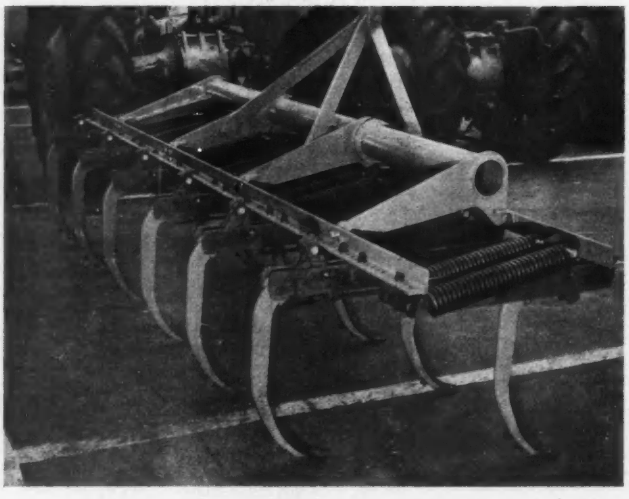


Fig. 1—Massey-Ferguson thirteen-tine tiller

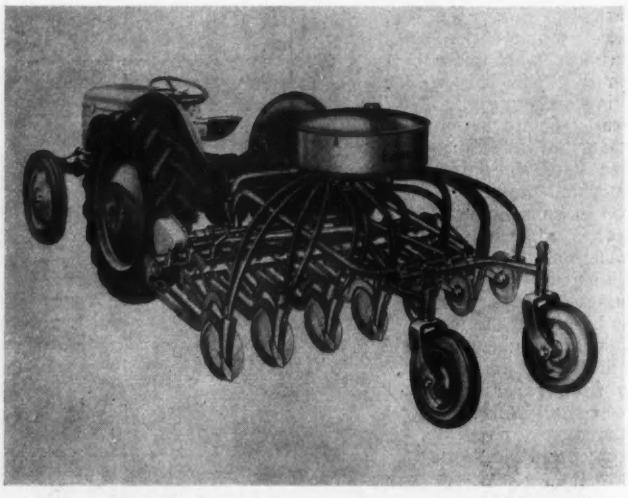


Fig. 2—Bamford precision seed and fertiliser drill

Fig. 3—Mobile " in-sack " grain dryer assembly

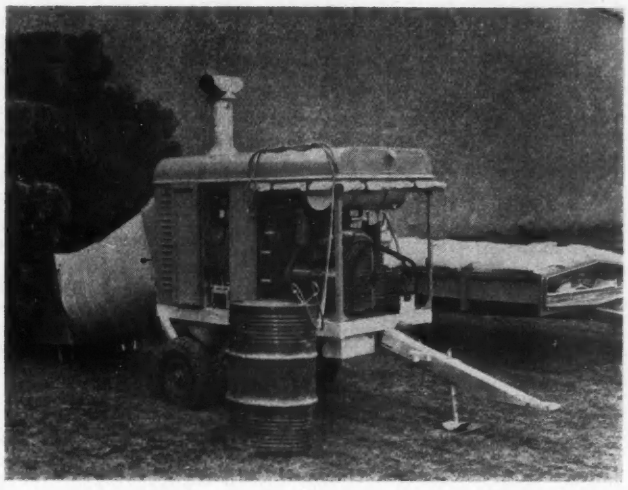


Fig. 4—The Trojan " Airator " for crop and grain conditioning

by strong springs so that even and constant sowing depth can be maintained even on land of irregular contours. Seventeen drill tubes can be fitted to the feeding mechanism manifold. The drill is assembled on a fabricated tubular frame and the whole machine has been designed with a low centre of gravity to assist stability. Pneumatic tyres are fitted to the two swivel castor wheels on each side of the machine and these wheels can be adjusted to suit various row widths.

Grain and Crop Drying

The widespread use of combine-harvesters —there are now about 33,000 working in this country—has compelled more and more attention to be given to grain drying and storage. The matter has become of even greater importance during the last two years when the grain harvesting seasons have been wet! There are several exhibits at the Smithfield Show this year which exemplify the progress being made in the design of grain and crop drying equipment. Some of these dryers have been devised on the " continuous flow " principle, i.e. the drying grain moves along the floor of a trough that is placed at a height convenient for inspection and for sacking the dried grain. A dryer of this description is shown by Gascoignes, Ltd., Reading. In this equipment the hopper which receives the grain to be dried incorporates two cleaning screens which remove trash and dust and deflect the grain into a drying trough ; the depth of grain in the hopper is controlled by an adjustable overflow weir. The grain is moved along by a reciprocating action of the trough beneath which there is a chamber through which hot air is blown continuously. A refractory-lined furnace, heated by a " Swirlamizer " burner, is provided with a flame-failure cut-out. At the end of the hot-air section of the dryer a gate is fitted to control delivery of the grain to the cooling section.

There are, however, some other systems of grain drying demonstrated at Earls Court. In some places—small farms, for example—it is still customary to store grain in sacks until it is collected for milling, and to deal with drying under those conditions the Jeffery Engineering Company, Ltd., Thickwood, Chippenham, Wilts, has produced the equipment illustrated in Fig. 3. As will be noted from the illustration, the drying equipment, which is carried on a welded steel frame fitted with castor wheels, straddles a row of ten sacks at a time. Two models of this dryer are made, one, a completely mobile unit, with an engine-driven fan and Calor gas heating, and the other, with an electrically operated fan and heating unit. The actual drying is accomplished by the series of probes which are inserted to the full depth of the sacks. These probes, which are perforated over more than half of their length, release into the grain sacks the warm air generated by the heater. The main duct of the dryer is detachable and the outrigger support can be moved up and bolted to the heating unit to enable easy movement and storage.

Another mobile " crop and grain conditioner " which has been introduced recently is the " Airator " (Fig. 4), which is made by Trojan, Ltd., Purley Way, Croydon. This equipment, which supplies either cold or warm air, can serve a number of points on a farm and treat crops on sack platforms, in silos, barns, bins and ventilated floors with equal facility. Its design incorporates a diesel-engine-driven fan which sends a large volume of air through a heat exchanger and on into any suitable form of ducting leading to the crop-conditioning station.

The " Airator " is built up on a fabricated steel chassis carried on pneumatic tyres and fitted with a tow-bar on which a jack leg is mounted. A 10 h.p. single-cylinder, air-cooled diesel engine at one end of the chassis is coupled to an axial-flow fan which is designed to deliver from 6000 to 12,000 cubic feet of air per minute at 1·5in static water gauge through a cross-flow tubular heat exchanger.

Hot gases are supplied to the tube system of the heat exchanger from a combustion chamber in the base. This refractory-lined steel plate combustion chamber has a jet burner assembly at one end and the pressure jet, in which diesel fuel is atomised, is ignited by electrodes coupled to a magneto. Combustion air is provided to the burner by an off-take from the main fan delivery through the heat exchanger body. Diesel fuel is used in the burner and is drawn from a 40-gallon drum at the side of the chassis by a pump driven from the engine. The hot gases, after passing through the heat exchanger tubes, and the exhaust from the diesel engine, are discharged through a T-cowled flue above the exchanger. The hot air passes from the heat exchanger through a large connection duct to flexible trunks, which can be adapted to the class of drying operation involved. Calibrated air flow shutters are provided in the outlet duct and the overall performance of the equipment is determined by a combination of shutter air flow setting and fuel feed setting. A solenoid fuel valve is operated from a dynamo, and a delay action when shutting down ensures that the combustion chamber is purged before the fan stops.

The makers state that the heat exchanger is designed to transfer up to a 26 deg. Fah. rise in 12,000 cubic feet of air per minute. On typical duties it is stated that with a consumption of ½ gallon of fuel per hour 12,000 cubic feet of air per minute can be delivered at a dry bulb temperature of 65 deg. Fah., the maximum extraction rate being 60 lb of water per hour. When burning 2¾ gallons of fuel per hour a similar volume of air can be delivered at 90 deg. Fah. dry bulb temperature with a maximum water extraction rate of 244 lb per hour. These

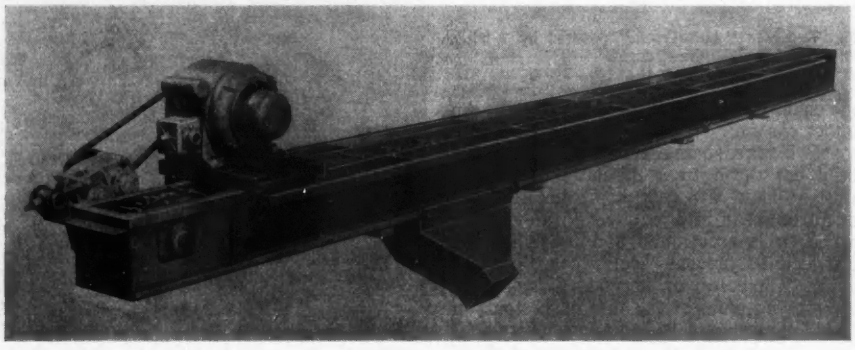


Fig. 5—Whitlock grain conveyor

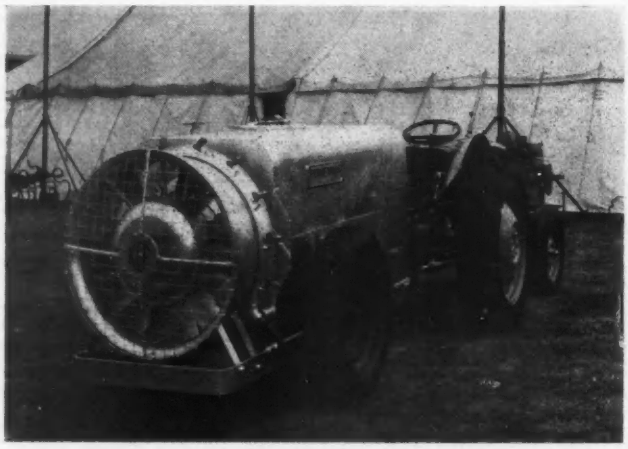


Fig. 6—The "Powermist" sprayer fitted with 200-gallon tank

rates are quoted with ambient air at 65 deg. Fah. dry bulb and 75 per cent relative humidity.

Grain drying on a large scale and the bulk storage of grain are operations which are assisted by the installation of suitable conveyor systems. This year, Whitlock Brothers, Ltd., Great Yeldham, Essex, has introduced an electrically-driven chain conveyor which is said to have been designed not only for large capacity, but also for speedy installation. The sides are tapered to allow the grain to be fed into the base of the conveyor, at any point, without "splash-back," and the use of special intake hoppers is thereby avoided.

The pressed steel sides of the conveyor (Fig. 5) are bolted to a hardwood base and

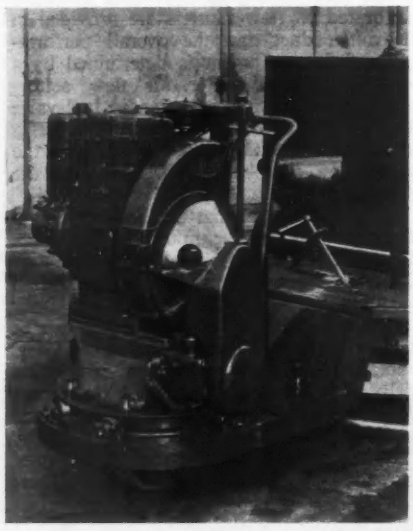


Fig. 7—Lister "Auto-Truck," powered by 7 b.h.p. diesel engine

the chain runners are also of hardwood. An outlet can quickly be fitted in position with toggle clamps so that initial site fitting has been cut down to a minimum, only two straight hand-saw cuts being necessary to fit an outlet in any required position. The carrier rails are slotted and brush gear is provided to prevent "carry over" of the grain. The conveyor, it is stated, is suitable for moving grain at the rate of 12 tons an hour, requiring only ½ h.p. for every 25ft run; it may be fitted at an inclined angle of up to 10 deg. without appreciable loss of capacity. The heavy conveyor chain which is used is driven through a totally enclosed reduction gearbox. The end sprockets are readily adjustable and run in self-aligning ball bearings.

Some Other Equipment

In this article we have surveyed briefly a few of the many machines and implements which the engineering industry now produces for mechanised farming. There are several other kinds of equipment which, of course, could equally well be mentioned and which have been on show this week at Earls Court. Some of the prominent exhibits are those of crop-spraying equipment. The example of this kind of equipment which we illustrate in Fig 6 is the "Powermist" manufactured by Kent Engineering and Foundry, Ltd., Maidstone. It has been designed for operation by medium-power tractors. The machine, which is driven by the tractor power take-off, incorporates a 200-gallon tank with a mechanical agitator, and a porcelain-lined pump which delivers 16 gallons a minute at 250 lb per square inch. An air stream is created by an aluminium multi-blade fan and the "Lyunet" nozzles, by ejecting the liquid into the side of the air stream, produce a continuous spray of very fine droplets.

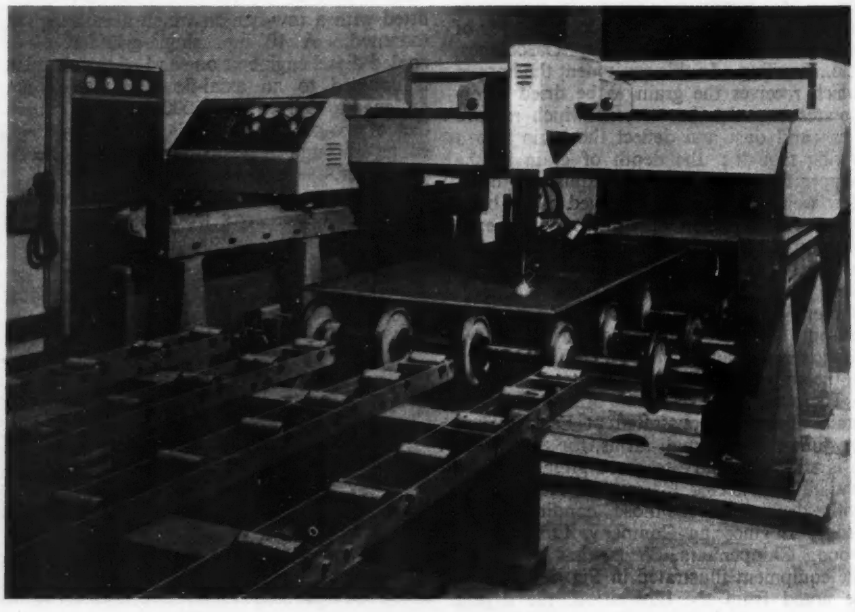
Finally, a word must be said about the increasing awareness throughout agriculture of the time and labour involved in materials handling. At the Smithfield Show there can be seen a number of loaders, tractor operated and otherwise, and many examples of tipping trucks and trailers. There are obviously many duties on a farm for an industrial truck like that shown by R. A. Lister and Co., Ltd., Dursley, Glos (Fig. 7). This new version of the "Auto-Truck" is fitted with the Lister LD2 twin-cylinder, air-cooled diesel engine, which develops 7 b.h.p. at a speed of 1800 r.p.m. Drive and operational control have been simply designed. A single-plate clutch with carbon thrust pad is mounted directly on the engine flywheel and is operated by a hand lever and flexible cable. Primary drive is by ½in pitch roller chain with a tensioning device, and thence through a gearbox giving two forward speeds and reverse. There is a gear reduction drive to the road wheel, which is fitted with a heavy-duty pneumatic tyre.

This road wheel, incidentally, consists of two pressed steel flanges bolted together, but easily separated for fitting or removing the tyre. Furthermore, the complete wheel and tyre can be removed from the hub in one piece. The internal expanding brake is operated by a ratchet hand lever.

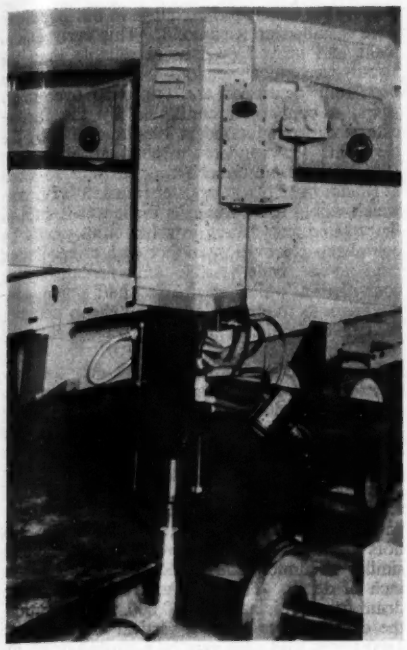
All driving controls—clutch, brake and speed control levers—are mounted adjacent to the steering bar.

Computer-Controlled Flame Cutting Machine

IN a demonstration recently given at the works of British Oxygen Gases, Ltd., (Equipment Division) Edmonton, London, N.18, there was shown a prototype flame cutting equipment incorporating Ferranti computer control, which has been developed for profiling steel plates in shipyards. In introducing this equipment the maker points out that, in addition to eliminating many of the stages required in the conventional practice of producing profiled plates in shipyards, a consistent degree of accuracy is maintained. With computer control the machine receives its instructions from a



Experimental computer-controlled flame profiling machine for ships' plates



Transverse carriage and cutter head of machine. The cutting assembly includes a nozzle height sensing probe, flame cutter, ignition electrode and flame monitoring unit

magnetic tape and the operation thereafter is entirely automatic as to shape, correction of error, and monitoring of the services supplying the cutting machine.

In practice with this Ferranti control system, the part to be profiled is designed and drawn in the conventional manner, except in that in place of dimensions specified as lengths between points all dimensions are given as positions relative to the axes about which the machine works. A planning sheet prepared from the drawing gives the input information for the computer in normal terms and includes such details as required cutting speed, kerf width, pre-heat time, and so on ; it also includes the data regarding points of change and types of curve from the drawing in the order in which the profiling operations are to take place. When this planning sheet is complete with every movement necessary to produce the part specified, the information is coded so as to be in a form suitable for use as input to the computer. For this purpose a teleprinter is used and copy-typing only is involved. This teleprinter produces a paper strip with a pattern of holes, the number and position of which correspond to the code ; it also produces typed information which can be cross-checked with the planning sheet. The information on the paper tape is then transferred by the computer on to a magnetic tape for use in the control console of the cutting machine. When the tape has been inserted in the control console the centre of the cutting nozzle is located at the datum position, which will normally be the origin of the system of axes used in planning, with the workpiece located against stops which are fixed in relation to the datum. The machine can then proceed with the cutting operation under the control of the magnetic tape alone. In addition to the positional monitoring along the axes, other controls include continuous nozzle height sensing in order to preserve the correct distance between the cutting nozzle and the plate. A flame monitoring unit confirms the presence of a pre-heat flame, and this unit in the event of failure automatically shuts down the system and stops the machine. A restart sequence can be initiated immediately in these circumstances. An automatic ignition system also lights the gases on receipt of the command impulse from the magnetic tape.

Automatic monitoring of the performance of the control unit is continuously maintained so that if for any cause, such as supply or component failure, some part of the equipment ceases to function, the machine will shut down before the work is spoilt.

The machine which has been developed for experimental work on automatic flame profiling can be seen in the accompanying illustration ; it is restricted to square cuts on plates up to 6ft by 7ft in size with a maximum thickness of 2in. This small portal design machine with a single nozzle, has been fitted with an elementary work table area comprising three individual sections for the loading, cutting and discharge of a workpiece. The makers point out, however, that the main features of what will later become the production machine are incorporated in this prototype model, including computer control of both axes of motion of the machine, height sensing, flame monitoring, and a balanced gas control system. The differences between the experimental and the production versions of the machine will mainly be in layout and size, the production machine being of the port-and-starboard type with a capacity for cutting plates up to 12ft by 40ft on each side. It will have power-driven rollers to move the plate from the marshalling area up to stops on the cutting area, and after the cutting operation the plate will be carried forwards to a 50ft long discharge area.

It is anticipated that computer controlled flame cutting equipment will have many applications in the structural engineering field, steel fabrication plants and other branches of industry where plate cutting and manipulation are involved. To relieve manufacturers of the necessity of installing computers, a central service has been set up on which users can purchase time. With this service coded paper tapes can be sent to the computer centre, which will prepare the necessary reels of magnetic tape for use on the control consoles of machines on a twenty-four hours service basis.

Mark "AL" Diesel Engines

AFTER making a careful study of the requirements of shipowners with regard to the powering of ships for different services, such as coaster, short sea traders, trawlers and tugs, Mirrlees, Bickerton and Day, Ltd., Stockport, has designed a new range of diesel engines. These vertical in-line units, developed from the "K" engine and given the mark "AL," are essentially intended for marine purposes, and have a bore of 19in by a stroke of 27in. The pistons are oil cooled and the four valve cylinder head is similar to that of the "K" engine except that the water cooling system is modified, while each cylinder is fitted with a decompressor braking valve independent of the relief valve. The engines are exhaust gas turbo pressure charged with intercooling and designed to burn heavy fuel oil of 3000 seconds Redwood 1, at 100 deg. Fah. Bryce fuel injection equipment is fitted and the design provides for a separate fuel pump for each cylinder. At no load the compression pressure is about 420 lb per square inch, the corresponding pressure at full load being between 630 lb and 650 lb per square inch while the maximum pressure is approximately 1050 lb per square inch.

Initially the engine will operate at a designed brake mean effective pressure of 138 lb per square inch, but it is intended that this will be subsequently raised to 150 lb per square inch. It is planned to build engines having from six to ten cylinders and, from the accompanying table giving the details of the power developed by the engines, it can be seen that the range of output at the lower brake mean effective pressure is from 1600 s.h.p. at 200 r.p.m. to 4000 s.h.p. at 300 r.p.m., while at the higher value the range is from 1745 to 4340 s.h.p.

An important item in the design of the engine is the provision of pneumatically operated reversing gear which enables the change from ahead to astern to be effected by one movement. The gear driven camshaft has one ahead and one astern cam for each cylinder, enabling the cam follower to give ahead or astern rotation in one motion. Lever operated instead of handwheel controls have been adopted. A pressure lubrication system is installed but lubrication of the rocker gear on the cylinder heads is arranged to be independent of the main system. It is expected that the first engine, a six-cylinder unit, will be ready in May of next year for shop trials.

B.m.e.p.—138 lb per square inch

R.p.m.	Number of Cylinders				
	6	7	8	9	10
200	1600	1864	2125	2400	2665
210	1680	1960	2230	2520	2800
230	1840	2145	2450	2760	3065
250	2000	2330	2665	3000	3330
275	2200	2570	2930	3300	3670
300	2400	2800	3200	3600	4000

B.m.e.p.—150 lb per square inch

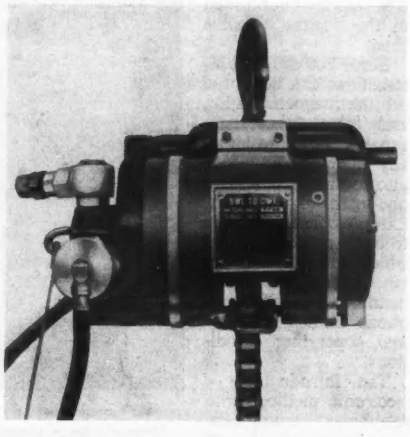
200	1745	2025	2310	2610	2890
210	1830	2125	2425	2740	3035
230	1995	2325	2660	2980	3320
250	2170	2530	2890	3250	3610
275	2835	2780	3180	3580	3975
300	2600	3035	3470	3900	4340

S.H.P. Output of "AL" engines

Air-Operated Hoist

OUR illustration shows a 10 cwt hoist, operated by air at 80 lb per square inch, which was displayed by Broom and Wade, Ltd., at the Building Exhibition. The ARO-Broomwade "Mini-Hoist" has a speed of 25ft per minute at full load, consuming 30 cubic feet free air per minute and the standard lift is 8ft.

The version illustrated is controlled by a pendant hanging on the wire seen on left ; two valves on the pendant are connected by hoses to two motors on the ends of the valve shuttle to select "up" or "down." The shuttle is geared to the shaft running along the bottom of the hoist, which carries a bar straddling the chain to stop the hoist at the extremes of chain travel. The end of this shaft engages the mechanical brake, with bonded lining, on the air motor shaft ; an alternative form of control consists of two cords hanging from the ends of the cross bar, and with this device a load can be lowered without air supply.



This compressed air hoist weighs 34 lb and will lift 10 cwt at 25ft per minute

The hoist motor is of vane pattern, and its shaft passes through the lifting sprocket. Between the friction brake and the sprocket is a planetary reduction, the motor driving the sun wheel and the annulus being mounted on the sprocket, which runs in two ball bearings.

Magnetic Drum Automatic Telephone Equipment

ELECTRONIC equipment capable of routing over a hundred telephone calls to different destinations simultaneously began operating at the Lee Green (London, S.E.13) automatic exchange on November 28.

The equipment, which is expected to make an important contribution to the Post Office's plans for the widespread introduction of automation, is the first of its kind to go into operation in this country. It employs a "magnetic drum" storage device similar to those used in the latest types of computers, which can "remember" numbers and translate them into routing instructions quicker and more efficiently than a team of several of the most skilled manual switchboard operators. In order that the rare mistake should not go undetected, it has its own built-in supervisory circuits which flash alarms whenever something is amiss.

Known as the Magnetic Drum Director, this electronic telephone controlling equipment has been developed by Automatic Telephone and Electric Company, Ltd., of London and Liverpool, and is claimed to be a noteworthy technical improvement on the existing electro-mechanical equipment in use in London and elsewhere throughout the world. Its functions are, however, basically the same—it must "store" the dialled numbers, translate them into routing directions, and ensure that calls are put through in the shortest possible time.

Some 700 different instructions can be stored on the magnetic drum, and from these it is capable of translating any demand for a call into routing data in only one-tenth of a second. Extensive field trials are to be carried out, during which performance will be closely studied, handling public telephone traffic under normal operating conditions.

The introduction of electronic methods into telephone automation constitutes an important advance, inasmuch as, in general, the various systems of automatic telephone switching, providing service to most of the world's 110 million telephone subscribers, may be said to have now reached a state as near perfection as is permitted by the electro-mechanical methods which they employ. Even before the war telecommunication engineers began to see the possibilities of switching without the use of relays and similar mechanisms and at present a large number of static devices and techniques are available.

As Sir Lionel H. Harris, Engineer-in-Chief of the Post Office, said at the inauguration of the Magnetic Drum Director, before a decision to adopt such systems could be made it must be evident that eventually overall advantages and economies beyond anything attainable by the continuance of electromagnetic methods would result. Considerations of space, cost, maintenance, reliability and facilities, together with any repercussions on external plant practices and economies and on training, all needed to be assessed. Many Post Office engineers believed that, viewed comprehensively, electronic methods of switching would eventually lead to new levels of attainment and would meet also the probable requirement of higher frequency operation of the cable network. In Britain since the war the Post Office and manufacturers of exchange equipment had studied the problem; latterly all had pooled their research and development resources in this field. The firms concerned were: Automatic Telephone and Electric Company, Ltd.; Ericsson Telephones, Ltd.; General Electric Company, Ltd.; Siemens Edison Swan, Ltd., and Standard Telephones and Cables, Ltd.

Magnetic drum director, with drum behind lower right-hand panel. This equipment can be time-shared by over 114 switch control units. Translations (i.e. routine instructions) can readily be changed without any rewiring, by means of the key panel (centre), after which a check is made by dialling a number, as shown here

Various electronic and semi-electronic exchanges had been built and operated since the war within these industrial organisations, but now a concerted effort was being made to design a system suitable for the public service of the future with all its complications. It was anticipated that a trial exchange would be opened early in 1960 at Highgate Woods, which would provide information much beyond that which could be obtained in the laboratories.

In addition to the development of complete exchanges, Sir Lionel said, the Post Office had been greatly interested in the development of electronic equipment ancillary to the existing system. As early as 1952, electronic versions of "directors" which register, translate and route calls from exchange to exchange in our big cities, were installed at Richmond. This early equipment had proved even more reliable than the electro-mechanical versions which had by then been fully developed and improved over many years, a conclusion confirmed by the further extension at Richmond in 1954 and also by the electronic key senders installed at Thanet in 1955. When Subscriber Trunk Dialling is opened at Bristol in 1959, the register translators (Grace) which would route the calls dialled at Bristol to the wanted subscribers in other cities would be completely electronic. In fact, Subscriber Trunk Dialling was made possible fundamentally by the contribution which electronics had made over the years to the provision of the cheap network of trunk circuits which had been built and mechanised since the war.

The magnetic drum around which the new electronic director has been constructed consists of a bronze cylinder some 12in in diameter and about 3in deep. Its working surface is coated with approximately two ten-thousandths of an inch of nickel which forms the medium for the magnetic records. These records consist of sequences of magnetic "dots" which can be packed closely enough together to obtain 100 dots to the inch of circumference and at least ten similar circumferential "tracks" of dots to the inch of depth. Thus, the total capacity of the drum for dots is at least 110,000. In operation, the drum rotates about a vertical axis at about 1800 r.p.m. and dots may be recorded or reproduced at a rate of about 100,000 dots per second.

The magnetic dots are coded into numbers and instructions in binary code; in this way, four dots are required to record a single digit, and seven sets of four dots to record a seven-digit number such as would be dialled by a caller.

The drum records are used in two ways. Some of the thirty tracks are used for remembering the translations likely to be required—about 700 in all. These records are virtually permanent in the sense that they are changed only when, for administrative reasons, it is necessary to alter a translation. The remainder of the tracks are used as control tracks—some provide the means for synchronising the operation of the complete equipment—the others provide individual memories for switch control units, of which there are 114.

The electronic equipment associated with the drum contains a scanner, driven by the synchronising tracks, which, among other things, causes each switch control unit to be associated in turn with the particular portion of one of the tracks allotted to it. The switch control memory tracks provide means for keeping a running record of the state of each control unit and by continuously checking this running record the electronic equipment can determine what action is next required in each case.

The running record is kept up to date merely by recording the most recent record in place of the old one. In this way the electronic equipment and the drum can be time shared over 114 switch control units in as little as 17 milliseconds each without interfering with any other. Moreover, each of the 114 control units can be rescanned every 17 milliseconds so that changes of state of up to sixty changes per second are recognised. This permits considerable economies in apparatus and is one of the reasons for developing the trial equipment. The translation tracks are referred to whenever a switch control unit reaches an appropriate condition.

INDUSTRIAL FRICTION MATERIAL.—A new woven asbestos friction material, Ferodo ZA.1, has been specially developed for industrial and mining applications, such as winding and haulage gear, where high temperatures and arduous working conditions are encountered and comparatively soft brake paths are in use. Extensive field tests have shown that the material, which has a zinc wire inclusion, has a stable coefficient of friction of 0·38 to 0·4, and is suitable for use at temperatures up to 300 deg. Cent. (572 deg. Fah.). A notable characteristic is its relatively high degree of flexibility, which not only helps eliminate squeal and judder, but also allows it to be easily formed to radius on the site without using special tools. Ferodo ZA.1 is available in roll form up to 20in wide and in thicknesses ranging from ¼in to 1in.

Industrial and Labour Notes

Ministry of Supply and the Aircraft Industry

In response to questions in the House of Commons on Monday last, Mr. Aubrey Jones, Minister of Supply, expressed his belief that any technicians, scientists and engineers redundant to the aircraft industry were in demand elsewhere. Asked about the future of the industry, he said that any increase likely in the production of civil aircraft would not offset the expected decline in military production. An inter-departmental examination of the problems facing the industry, and of the future of Government policy on aeronautical research, was in progress, and the Transport Aircraft Requirements Committee had invited the S.B.A.C. to join in its discussions. It was the policy of the Ministry to require that any contractor should have adequate resources in his own or associated firms before placing an order. Mr. Beswick suggested that the inter-departmental inquiry would be conducted by the people largely responsible for the present position of the industry, and that outside people should be consulted: the Minister was satisfied with the existing proposal, since a wider inquiry would be less likely to reach a speedy decision. The Minister advocated second thoughts before disbanding the Ministry of Supply, which he described as a highly important scientific organisation.

Changes in Wage Rates

A report published in the *Ministry of Labour Gazette* shows that changes in wage rates which came into operation in the United Kingdom during October resulted in an aggregate increase of about £330,000 in the weekly full-time wages of 930,000 workpeople, and in a decrease of about £17,000 for 262,000 workpeople. The decreases affected mainly iron and steel workers and hosiery workers in the Midlands and Scotland. They resulted from sliding-scale arrangements based on the index of retail prices.

The Ministry of Labour says that in the first ten months of this year changes in wage rates led to an aggregate increase of £5,006,000 in the weekly full-time wages of about 11,716,500 workpeople. In the comparable period of 1956, there was a net increase of £6,340,000 in the weekly full-time rates of wages of 12,039,000 workpeople. At the end of October, the index of rates of wages (January 31, 1956=100) stood at 112 for all workers; it was one point higher than in September.

The same report notes a reduction of hours in some sections of the iron and steel industry. Normal weekly working hours for process workers in the heavy steel industry employed on the rotating shift system at blast-furnaces and in melting shops and heating departments of mills, were reduced from five-and-a-half shifts or forty-four hours, to an average of five-and-a-quarter shifts, or forty-two hours. This reduction applied also to workpeople employed at coke oven plants attached to blast-furnaces.

Industrial Disputes

According to statistics issued by the Ministry of Labour, there were 257 stoppages of work through industrial disputes which began in October in the United Kingdom. In addition, there were still in progress at the beginning of the month twenty-six stoppages which had started earlier. In these 283 stoppages, the Ministry says, the number of workpeople directly and indirectly involved was 39,900 and the aggregate number of working days lost was 119,000.

The Ministry states also that of the 257 stoppages of work which ended during October, 128 directly involving 8200 workers, lasted not more than one day; fifty-six, involving 9400 workers, lasted two days; twenty-five, involving 4800 workers, lasted three days; twenty-six, involving 5000 workers, lasted from four to six days; and twenty-two stoppages, involving 6800 workers, lasted for more than six days.

In the first ten months of this year 8,273,000 working days were lost in the aggregate on account of 2401 stoppages which involved 1,286,500 workers. In the corresponding period of last year, the loss of time amounted to 1,983,000 working days, there having been 2321 stoppages affecting 473,400 workers.

Iron and Steel Import Duties

The Board of Trade has announced that under the Import Duties (Exemptions) (No. 6) Order, 1957, the import duties on blast-furnace ferro-manganese and on a wide range of iron and steel products are suspended until March 18, 1958. Under the Import Duties (Exemptions) (No. 10) and (No. 12) Orders, 1957, duties are suspended until September 18, 1958, on plate and on cold reduced sheet of a value of less than £90 a ton. After consultation with the Iron and Steel Board about the supply position, the Government has decided to prolong until September 18, 1958, with some exceptions, the suspension of import duties in respect of those other iron and steel products where duty is now suspended. The exceptions, on which duty will be restored on March 19, 1958, are blast-furnace ferro-manganese and sheet (other than the cold reduced sheet already mentioned and wide hot rolled strip in coils). A new Order entitled the Import Duties (Exemptions) (No. 16) Order, 1957 (S.I. 1957, No. 2045), has been made and will come into operation on March 19, 1958.

Shipyard Mission to India

The Shipbuilding Mission, which recently went to India under the joint auspices of the Colombo Plan and the United Kingdom Shipbuilding Conference, to advise the Government of India on the site and layout of the second shipyard, has now returned to the United Kingdom after its three weeks' visit. The advance party and main mission between them inspected thirteen sites, of which eight were visited by the main party, two at Calcutta, three at Karwar, and one each at Cochin, Bombay and Kandla. The mission also visited the Hindustan shipyard at Visakhapatnam to obtain general information on the layout of the shipyard and its operation.

A statement on the work of the mission says that many of the sites inspected clearly have the essential requirements needed for a shipyard. But communications and the supply of labour will no doubt be a major factor in arriving at a final decision. The mission spent its third week at New Delhi in discussions with the Indian Ministry of Transport and Communications and other departments concerned with education, heavy industries, railways and steel production. Before leaving for the United Kingdom, Mr. James Lenaghan, the leader of the mission, had an interview with Mr. Nehru.

The members of the mission found the authorities in the areas visited helpful and ready to provide full information. Plans will now be drawn up for the site which the mission considers most suitable, together with a comprehensive statement of costs covering not only the preliminary civil engineering work, but also the cost of all buildings and plant required. The shipyard will be planned on the most up-to-date lines and will provide considerable employment, using materials produced by many industries in India. It is expected that the mission's report will be submitted to the Government of India before the end of March next year.

Oil Consumption

The Petroleum Information Bureau has stated that the United Kingdom demand for petroleum products has recently been surpassing the 1956 level. Between July and September, deliveries into consumption were in fact up by 1·1 per cent on the corresponding quarter of last year. The Bureau's figures show, however, that owing to the lower level of supplies in the first half of 1957, due to rationing and other restrictions, total deliveries for the first nine months (17,671,480 tons) were down by 5·5 per cent on those of the preceding year.

The greatest contribution to the small increase achieved in the third quarter was made by gas/diesel oil (up by 7 per cent) and fuel oil (up by 11 per cent, excluding refinery usage). Over the nine-month period, however, deliveries of gas/diesel and fuel oils, including oil consumed in the refineries, were down by 2·6 per cent, to 7,799,397 tons. After fuel oil, the largest consumption of any product related to motor spirit, which between January and September totalled 4,253,066 tons, a fall of 12·2 per cent on the 1956 level. Requirements of standard grades, now appreciably less than half of all the motor spirit sold, declined more than those of premier grades and the latter actually showed a rise of 1·4 per cent on last year's figures during the July-September quarter. There was also an increase over the same period in deliveries of diesel-engined road vehicle fuel, which were up by 3·3 per cent. But, owing to the large drop in consumption during January-March, the total for the first nine months of 1957 was slightly below the corresponding 1956 level. Sales of burning oil and vaporising oil were both lower during the third quarter, and over the first nine months of the year the former (477,886 tons) decreased by 13·6 per cent over 1956 and the latter (418,827 tons) was 4·3 per cent less than last year; but whereas vaporising oil deliveries have been falling for several years, those of burning oils were rising steadily up to the time of the Suez crisis. There was likewise a decline during the first nine months of 1957 in demand for aviation fuels (1,240,028 tons) and lubricating oils (612,645 tons), figures which were, respectively, 7·8 per cent and 5·7 per cent below the comparable figures for last year.

International Instrument Congress and Exhibition

No. II—(*Concluded from page 764, November 22*)

From November 2 to 10, the "Interkama 1957" (Internationaler Kongress mit Ausstellung für Messtechnik und Automatik) was held in Düsseldorf. This international congress, with exhibition of measuring instruments and automation, was the first of its kind to be held in Germany. Some 179 German and 149 foreign firms from eleven countries took part in the exhibition which, both by the way in which it was presented and by the interest which it aroused, must be regarded as a success.

SIEMENS AND HALSKE A.G., AND SIEMENS-SCHUCKERTWERKE A.G.

ON the stand of Siemens and Halske A.G. and Siemens-Schuckertwerke A.G., Berlin-Munich-Erlangen, were shown a large number both of measuring instruments and apparatus as well as complete models and demonstration set-ups from the fields of energy production and process technology. Of particular interest among the former were a portable meter for magnetic field strengths of 50 to 20,000 Oersted, based on the Hall effect.

The fact that many measured quantities have not only to be read and recorded, but form the basis of further calculations, has led to the development of equipment which stores these results or feeds them to calculating machines, prints them in tables, or sends them out in spoken form over the telephone upon demand. The first step is to convert the instrument indication which forms an analogue of the quantity to be measured, into the digital form. Coding equipment shown in combination with a teleprinter, printed on an ordinary 210mm by 297mm (DIN A4) page, besides the four-figure clock time up to twenty-five different three-figure results side by side. Other combinations up to 104 figures per line are possible. These measurements are taken automatically at preset intervals or under manual selection. Readings occurring at widely distant points can readily be obtained in a central control room over the normal telephone lines which usually are already in existence, or by ultra-short wave transmitter. In a demonstration set-up, a water level (e.g. that of a reservoir) was measured in the normal way by means of a float which operated three coupled range switches indicating the level in metres, decimetres and centimetres. (Where "quantitisation" in this manner is not possible, the analogue instrument indication must be converted into digital form by a special instrument, using relays.) As information store a magnetic disc recorder was employed which contained on concentric tracks the name of the station, the figures 0 to 9, and the units. On the station being dialled over the telephone, the disc reading heads were connected to the amplifier by means of relays in the sequence corresponding to the reading at the time.

The endeavour to make telemetering in extensive networks (e.g. in gas and water supply systems) as efficient as possible by using to the full existing channels of communication (cables, overhead lines, or wireless) has led to the development of carrier frequency systems which allow the multiple utilisation of such channels. While impulse frequency systems allow the transmission of up to twenty-four measurements, the "time multiplex method" multiplies several times the transmission capacity of a channel of the same bandwidth, at the cost of transmitting values discontinuously instead of continuously, but with rapid cyclic repetition. In the form shown by Siemens and Halske, up to twenty quantities can be transmitted on a 480 c/s wide channel, or 120 quantities on a speed frequency band. An installation comprises up to twenty transducers which represent the measured quantities as proportional d.c. voltages. A distributor applies these voltages to a transmitter with linear response which sends out pulses of 40 milliseconds, so that each cycle, including a synchronisation pulse of 40 milliseconds, occupies 840 milliseconds. A measurement range of 0–100 per cent corresponds to a bandwidth of 265 c/s, the synchronisation pulse to 85 c/s.

At the receiving station, the audio frequency pulses are changed back into proportional d.c. voltages by means of a frequency-modulated receiver and charging condensers, and distributed to their respective measurement points by a synchronised distributor. Besides transmission of single values, the system also permits the addition of one or more quantities from any source.

We can only briefly touch here upon the various designs of cathode-ray oscillograph which were exhibited by Siemens. Among new designs is the "Oscillar I ($x=y$)" with equal x and y deflections, for ferro-magnetic and valve measurements. An electronic switch permits the recording on a single-spot cathode-ray oscillograph of two quantities in rapid alternation. The switch can be operated from the oscillograph time base, at frequencies of 50 c/s to 500 kc/s, giving a picture free from flicker and harmonics. More than two quantities can be represented if extra switches are used, e.g. three quantities by using two switches, and so on.

An electronically controlled camera can register movements of the oscillograph spot of up to 400km per second, starting the exposure simultaneously with the commencement of the measurement.

Fig. 3—Moving coil oscillograph "Oscillofil 6," incorporating six miniature oscillograph movements —Siemens and Halske

For the registration of low-frequency phenomena of low energy, a moving coil oscillograph element has been developed which combines high sensitivity (up to 5·2mm/μA per metre), mechanical robustness and small size (it is about the size of a small pencil). It has a natural frequency of 120 c/s or 250 c/s and the absence of oil damping makes it suitable for use up to its full natural frequency. Two miniature oscillographs using this kind of element were shown for the first time, the "Oscillofil 16" and the "Oscillofil 6" (Fig. 3), for sixteen and six elements, respectively. An automatic developing machine allows for processing in the field.

Where indicating instruments are to be equipped with contacts to actuate alarms or control devices, the difficulty is to combine accuracy, robustness and the absence of any mechanical feedback which affects the reading. Devices which meet these requirements, like photocells, often need a complicated set-up to operate them. A novel design exhibited at the "Interkama" uses a light metallic vane fixed to the instrument pointer which moves into the space between the high frequency and feedback coils of a transistor oscillator. This interrupts the oscillations and thereby the d.c. output of about 1V. The smallness of the device which incorporates etched circuits, permits its use inside ordinary small instruments.

In the novel "Teleperm" control system there are no moving parts except the controlled member. Transducers and controllers employ inertialess magnetic electronic amplifiers. The measured quantity is converted into a proportional, impressed current which, to a large extent, is independent of the external load so that several indicators, recorders or controllers can be connected without needing any trimming. Special circuits are used to obtain a proportional-integral controller whose proportional range and time constant fall non-linearly with the deviation. This means that "noise" is suppressed without loss of sensitivity, as the controller is not sensitive to the amplitude of the disturbance, but to its energy.

For transmitting flow measurements to a central point, particularly where the danger of explosion exists, the "Telepnev" system has been developed, in which all quantities are transformed into air pressures in the range 0·2 to 1 atmospheres gauge, so that all controllers operate on the same input range. All components work on the principle of compensation and constitute interchangeable units.

In the field of temperature measurement important developments were the "Thermizet" portable contact thermometer for −20 deg. to +180 deg. Cent. (Fig. 4); the quick-response (1 millisecond) optical pyrometer "Ardofot S" (which uses a germanium photo-diode, and is used in rolling mills, or the control of flame and induction hardening), and multi-point compensating thermometers and selectors for up to 200 measuring points.

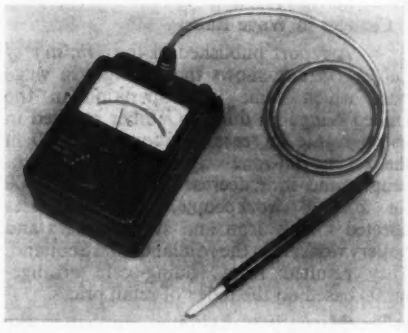


Fig. 4—"Thermizet" portable electric thermometer —Siemens and Halske

Of particular interest were the exhibits showing the application of remote and automatic control to power generation. An illuminated mimic panel of a pumping hydro-power station showed the effect of various commands upon the control organs. Also on show were the control system of a boiler turbo-generator unit of a thermal power station and the voltage regulation of synchronous generators by means of a new design of large-size controller.

Among recent applications of transistors might be mentioned the grid control of rectifiers in d.c. drives. Reliability and absence of inertia render the transistor particularly valuable in drives where a fast response is required. A demonstration set-up comprised a d.c. motor supplied from the three-phase mains by means of single-anode rectifiers, and controlled by a transistor controller and transistor grid control.

Starting the motor with constant acceleration, or with constant starting current, was demonstrated. The fast operation of current limitation was shown by connecting the motor at standstill to the fully biased rectifiers, and also by short circuiting the d.c. busbars when the grids were blocked immediately.

For the study of proposed control systems Siemens and Halske have developed a special analogue computer. This machine, shown in Fig. 5, does not require any programming other than the setting up of the diagrammatic circuit. The principle of plug-in function generators makes for great flexibility with the minimum of equipment. Transistor amplifiers use little power, save space, do not wear out and switch on instantaneously. Each of the identical units of which the equipment is built up contains an amplifier as well as variable capacities and resistances for adjusting respectively the "amplification" and the "time constant" of the circuit member which the unit represents. Voltages corresponding to disturbances and required values can be applied and the response recorded by the desk-mounted oscillograph.

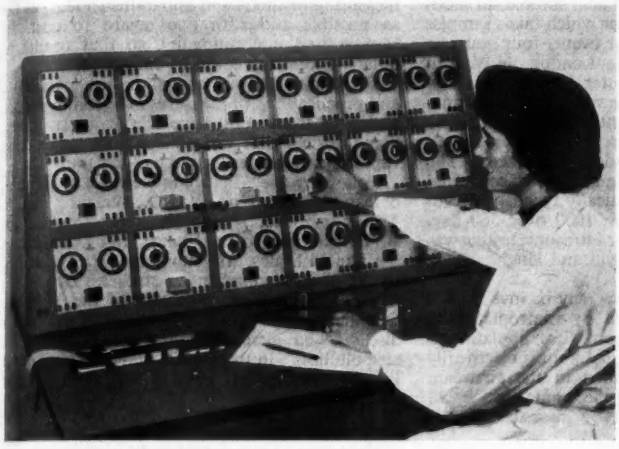


Fig. 5—The eighteen units of this analogue computer can be made to represent the components of a control system under study. Note the plug-in function generators, and the desk-mounted recorder—Siemens and Halske

Equipment for research and materials testing included, besides X-ray diffraction cameras, an ultrasonic tester with automatic fault signalling set. Much interest was aroused by the practical demonstration of the "Elmiskop I" electron microscope, which combines convenience of handling and ease of observation with a resolving power of one-millionth of a millimetre.

A.E.G.-Allgemeine Elektricitats-Gesellschaft

From the wide range of equipment shown on the stand of A.E.G. Allgemeine Elektricitätsgesellschaft, Berlin-Grunewald, we select for description a few which appear to be of particular technical interest. Of explosion-proof equipment—built to VDE rules and type—tested by the Physikalisch-Technische Bundesanstalt, a great variety was exhibited, including resistance transducers, Geiger-Müller tubes, and several designs of recorder.

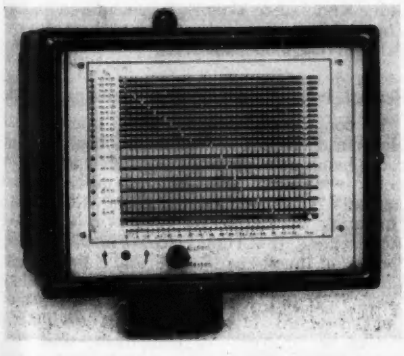


Fig. 6—Model "SAG" statistical indicator and counter, representing a frequency distribution diagram of the measured frequency—A.E.G.

The statistical indicator model "SAG" shows directly the frequency distribution with respect to time of any quantity which can be represented as a d.c. voltage, in particular, alternating currents and voltages, temperatures and electric power. Registration periods from forty to 10,000 hours are available, and the accuracy of reading is increased by having counters in addition to the graphical display. A permanent record can be made by pressing a sheet of paper against the indicator marks which are provided with points (Fig. 6).

The recording printer model "MD" prints at preselected intervals the readings of a number of meters, on an intermittently driven 40mm wide paper band. An installation for the chemical and pharmaceutical industry was shown, which permitted the counting of drops and the transmission of the count over a distance. The short photo-electric impulse from the light gate is electronically lengthened to operate the counter, which, by means of contacts, initiates sorting processes.

In the operation of d.c. equipment from a distant control room, difficulties can arise if high voltages are to be measured, as, e.g., telephone cables may not be used for tensions above 60V. A magnetic d.c. measurement transformer can be used to transform the high voltage or current into a low voltage or current without galvanic connection between input and output sides. The d.c. current to be measured passes through the two control windings of a choke, the main windings of which are supplied by an auxiliary a.c. and are in series with an output transformer. The transformer secondary current is rectified. This rectified current is always in a fixed ratio to the input current and is independent of voltage fluctuations of the auxiliary a.c. mains and of temperature. The two control windings oppose each other so that no net a.c. voltage is induced in them. Further control windings permit single sums and differences to be calculated. The instrument can also act as an amplifier.

A vibrating conveyor developed by A.E.G. feeds machines with small components which have to be presented item by item and in a fixed orientation. The equipment comprises an electrically supported base and above it a pot with a spiral conveyor chute ascending the inner cylindrical surface. The vibrator built into the base operates with small amplitude at about 100 c/s and causes the components to ascend the chute. Various devices return those components which have entered the wrong way up. The speed of operation is adjustable.

With continuous chemical processes it is desirable to be able to preset the composition of a mixture, while the actual total quantity should be automatically adjusted according to the variable production requirements. A demonstration set-up showed such an installation, in which two coloured solutions were added to a variable quantity of water, indicating the proportion of each component colour, the proportion of their sum (colour density), and the ratio of red and blue in the added volume (shade of colour), as well as the quantity of water flowing. The controls comprise magnetic transductors and magnetic and transistor amplifiers.

Where two or more reciprocating prime movers are used to drive synchronous generators in parallel, dangerous mechanical vibrations and undesirable voltage oscillations can be caused. These effects can be reduced by appropriate phasing of the engine crankshafts. As an example, A.E.G. showed the case of two single-cylinder engines (where the cranks must be phased at 180 deg.). Automatic phasing is done by first synchronising the incoming machine at any angle and measuring this angle by means of a differential selsyn. As long as the required angle is not reached, a contact remains closed which over relays causes continuous reversals of the exciter current. At each reversal the pole wheel slips by one pole division, until the correct angle is reached when the pole reversing contact is interrupted.

Telefunken G.m.b.H.

Telefunken G.m.b.H., Berlin, S.W.61, showed the turn counter "SP708" for electric windings from 0 to 21,110 turns with a stated accuracy of 1 to 3 per 1000 or better, according to the test range. The coil under test is placed over a suitable magnetic yoke and compared with a decade coil which, together with a 50 c/s exciter coil, is also placed on the same yoke. The same flux thus passes through test and comparison coil. The difference of the induced voltages is amplified and brought to a minimum by adjusting the comparison coil.

The contact quality tester "SP718," by the same firm, permits the rapid location of "dry" or otherwise faulty joints. A high-frequency current (3 kc/s to 1500 kc/s) is passed through the equipment under test and the output amplified. The joints under test are touched in turn by a vibrating probe. A faulty joint has the effect of modulating the output high frequency so that a noise is heard in the loudspeaker which is stated to be usually many times more marked than the similar noise which would occur during actual service.

For the integration of differential equations, of which exact solutions do not exist, and where numerical approximations would entail an excessive computing effort, the use of analogue computers is finding increasing favour. In this article we have already referred to equipment of this kind. At the "Interkama," Telefunken showed the "RA463/2" computer which, after a minimum of setting-up time, gives the result as a curve either on a cathode-ray oscillograph or on a recording oscillograph. The installation comprises linear as well as non-linear precision computing units which, like the ancillary units, can readily be plugged into racks. Normally, the machine has two computer cabinets and one output unit, but is so arranged that further computer units can be added. A special device allows any section of the graphical solution to be magnified to give an accuracy of measurement of 2 per 1000.

Brown, Boveri and Cie. A.G., Mannheim

Rapid adjustment of the electrodes of an electric furnace not only keeps the load more nearly constant, but also renders the melting process more efficient. A new hydraulic control valve designed by Brown, Boveri and Cie. A.G., Mannheim, the model "RVB," in combination with a fast controller gives response times of 0 to 30 milliseconds. It is laid out for 30 atmospheres and 12 litres per second of water, and enables electrode speeds of 200mm per second to be reached.

A multiple telemetering installation with cyclic transmission of readings was shown in operation. In this system, a medium frequency is adjusted in proportion to the measurement by varying the inductivity of the tuning coil of an oscillator. A bandwidth of $\pm 7{\cdot}5$ per cent is required, e.g. 1500 to 1750 c/s or 2200 to 2600 c/s. In the receiver, a discriminating circuit rectifies the a.c. voltages, the d.c. output being a measure of the original quantity. Since the receiver time constant is very small, the electronic synchronising distributor switches can operate at speeds of 6 milliseconds per step. Two steps being required for synchronisation and control, a ten-step unit can transmit eight measurements in 0·6 second, four such units thirty-eight measurements in 2·4 seconds. By using for synchronisation means similar to frequency

modulation, the danger of interference from stray e.m.f.s is eliminated. In place of one measurement the position of two switches can be transmitted.

FRIESEKE AND HOEPFNER G.M.B.H.

The "FH40H" radiation meter by Frieseke and Hoepfner, Erlangen-Bruck, is a pocket instrument equipped with Geiger-Müller counter, for measuring gamma or X-radiation from 0 to 1 roentgen per hour. The range can be extended to 10 roentgen per hour, and also to alpha and beta radiation. The shockproof instrument will run for fifty hours on a commercial 1·5V dry cell and is stated to have an accuracy of ±10 per cent.

The same firm has put on the market a special slide rule which facilitates the calculation of many quantities important in radiation protection.

ASKANIA-WERKE A.G.

On the stand of Askania-Werke A.G., Berlin-Friedenau, were shown representative examples of the firm's two main sectors of activity, instruments and controllers for thermal and chemical processes, and mechanical-optical precision instruments for special sciences such as geodesy, geophysics, oceanography and meteorology. The first class included flow, temperature and heat flow transmitters up to the highest working pressures, a space-saving hydraulic control unit in block construction, a portable recorder for measuring accelerations and decelerations during vehicle tests, photo-electric turbidity meters, and an instrument for the continuous recording and control of viscosity. The second group included the model in "Plexiglass" of a portable magnetic variograph as used in Antarctica during the present International Geophysical Year. This instrument is stated to record all three components of terrestrial magnetism with the same degree of accuracy as a fixed observatory. Among technical instruments the "Tu" second theodolite was stated to possess the most accurately divided circles for equipment of this kind, allowing direct reading to one second of arc, and estimated readings to 0·1 second of arc.

OFFICINE GUARDIGLI

A floatless level indicator for liquids or granular substances was shown by Officine Guardigli, Milan. The instrument depends on measuring the capacity of an insulated probe and uses two electronic tubes, one as a reserve. Versions for single or double indications are made. While the probe is connected to the instrument by a short co-axial cable, the moving coil indicator or recorder can be at a distance.

TURBO WERK

The firm of Turbo Werk, Cologne-Ehrenfeld, has put on the market a special flow controller which operates without any external power. The "Astur" mechanical controller has an action comprising a totally immersed stopcock rotated by an arm like that of a floating ball valve. The arm is actuated by a conical float situated in a parallel-sided discharge port. The drag upon the float, and, hence, the valve position, is regulated by some of the flow being by-passed round the float.

SOME BRITISH EXHIBITS

A large part of the stand of Electronic Instruments, Ltd., Richmond, Surrey, was devoted to the "Vibron" vibrating condenser unit and its applications. The device replaces the electrometer valve in the measurement of small currents and with appropriate accessories can be used for measuring currents down to 10^{-13}A and resistances of 5×10^{15} ohms. Another accessory converts the "Vibron" into a high-accuracy pH-meter, giving a 0·1 pH full-scale deflection over any part of the pH range and a zero stability of 0·001 pH. Designed for nuclear research, the "Vibron" electrometer model 33C is claimed to represent the practical limit in sensitivity, input resistance and zero stability for a direct reading electrometer. Also shown was a 20,000,000 megohmmeter, one of the series of direct-reading ohmmeters and megohmmeters covering from a fraction of a milliohm to 1000 million megohms and beyond.

The "Chronotron" range of millisecond timers was shown in a number of typical applications where accurate time measurement in the "split second" region is required.

Evans Electroselenium, Ltd., Harlow, showed a novel design of blood cell counter, yielding four counts of either red or white cells per minute. By averaging results an accuracy of better than 3 per cent is stated to be attainable.

A portable radioactive dust sampling device was exhibited by Fleming Radio (Developments), Ltd., Stevenage, with counting rates of 1, 10 and 100 per second, and integrating 10, 1000 or 10,000 counts. The same firm showed an automatic air pollution recorder which takes samples at intervals of one, eight or twenty-four hours.

Hilger and Watts, Ltd., London, N.W.1, in combination with the Foster Instrument Company, Ltd., Letchworth, showed the transformation of a circular movement into digital form by means of a digitiser, the movement being sensed by a "Frostronic" bridge resistance. The binary-coded digitiser signals were converted into decimals and automatically typed. Resolution was stated to be 1 in 1000 over 360 deg.

Automatic equipment for ultrasonic testing was one of the exhibits of Kelvin and Hughes, Ltd., London, E.10.

Microscale turbulent flow may be investigated by an instrument designed by Lintronic, Ltd., London, W.C.2, which comprises a platinum-coated glass wedge. The platinum is electrically heated, the effect of cooling in the airstream being compensated by an electronic feed back, so that the current gives a measure of the velocity.

By means of a special balance made by Stanton Instruments, Ltd., London, W.1, weight, time and temperature can be recorded simultaneously and continuously for periods up to several days. Applications include recording of ignition or similar studies, determination of moisture, volatile and ash, preparation of oxidation curves, oxidation rates on metal powders, evaporation rates of solvents, &c. The balance is air damped, and has a load capacity of 100 *g*, with a sensitivity of 1mg or 0·1mg. The standard furnace is suitable for 1000 deg. Cent.

World Health Organisation and Air Pollution

Twenty-one European countries were represented at a World Health Organisation conference in Milan from November 6 to 14 to consider air pollution. The aim of the conference was to pool the knowledge and experience of many countries in this field.

In addition to discussing the effects of air pollution on man, and on animal and plant life, the conference reviewed current legislation, research and abatement programmes in the participating countries. Engineering and measurement problems, industrialisation and town planning were also discussed.

The members of the conference were appointed by their respective Governments, those from Great Britain being Dr. Seiler (Edinburgh), Mr. W. A. Damon and Mr. Peter Isaac. Dr. J. L. Burn (Salford) acted as a rapporteur for W.H.O.

Among the main conclusions of the conference were that air pollution was recognised as the greatest and most urgent environmental evil facing the peoples and Governments of Europe. Much progress had been made in the provision of pure water, milk and food, and in improving housing; in air pollution, however, the necessary basic knowledge and control measures had lagged behind. Control was recognised as a difficult problem for all European countries—for some it was also a completely new and pressing problem. However, sufficient information was already available to enable decisive improvements to be made, and prevention and control of air pollution should be more vigorously pursued everywhere. Public health workers had an essential part to play in the initiation of preventive measures against new sources of pollution as well as in the abatement of existing air pollution. It was agreed that W.H.O. should arrange for the collection, translation, condensation and dissemination of information on air pollution, including, as a first stage, the compilation of a list of the various organisations and associations concerned with this problem. Countries that did not yet have some form of national advisory body on air pollution should set one up, and co-operation should be encouraged among the many different professions concerned with air pollution—public health personnel, chemists, engineers, town planners and industrialists. An endeavour should be made to reach agreement on terminology. There was need for an international glossary and for uniform, internationally acceptable expression of results. Basic sampling and measuring methods and apparatus should, as far as possible and with due regard to cost, be standardised internationally, so that results in different countries could be compared.

Great interest was shown in the possibility and practicability of measures designed to reduce pollution from motor vehicle exhaust gases. Some devices that will oxidise unburnt exhaust vapours are in experimental use on cars.

Following the Milan conference a committee of experts, called by W.H.O., met at Geneva. The committee, which is representative of Britain, South Africa, France, India, Italy and the United States, will submit to W.H.O. a full report of its comprehensive studies. Dr. P. M. Paul, assistant director-general of the W.H.O., said that recent studies of lung cancer and other diseases had increasingly focused attention on air pollution. In the United States, Canada and Britain the results pointed to a significant relationship.

Federation Européenne de la Manutention

A further meeting of Section II (Continuous Conveying) was held in Vienna on October 9–10, on the occasion of the Fifth European Congress of the Federation Européenne de la Manutention, at which the Austrian National Committee was the host there being present delegates from Austria, Belgium, Denmark, France, Germany, Great Britain, Saar, Sweden and Switzerland.

The programme of work embarked upon in Zürich on July 1 and 2 was continued. Three working groups were formed to deal with nomenclature, technical relations with users and suppliers, standardisation, &c. The sub-committee on nomenclature completed the first stage of its work which was a glossary of technical terms in seven languages of various types of conveying units. Nomenclature and illustrations will form part of a comprehensive dictionary of materials handling plant which is being compiled by the Federation.

Third International Harbour Congress

The Royal Association of Flemish Engineers, which now has a membership of over 2400, including 700 student members, will celebrate its thirtieth anniversary next year. In order to mark the occasion, it has been decided to hold the third International Harbour Congress at Antwerp during the period June 15 to 21, 1958. The business of the congress will be dealt with under the following heads :—harbour works, harbour equipment, handling and storing of goods, safety, and management. Details of the programme and all further information can be obtained from the secretariat at the headquarters of the Koninklijke Vlaamse Ingenieursvereniging, Torengebouw VIII, Schoenmarkt 31, Antwerp, Belgium (telephone, 33.65.23).

Second International Cargo Handling Week

In conjunction with the third International Harbour Congress, an exhibition dealing with cargo handling in general and cargo handling in ports in particular, is being organised by the Belgian National Committee of I.C.H.C.A. (International Cargo Handling Co-ordination Association). It will take place at Antwerp during the period June 14 to 24, 1958, and is to be called the "Second International Cargo Handling Week." It will, it is stated, include a series of demonstrations of actual devices or models related to problems of equipment, transport, transhipment, storage and packing. The Secretariat is at 1A, Korte Clarenstraat, Antwerp (telephone, 33.59.60).

Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

No. II—(*Continued from page* 805, *November* 29)

POWER DEMONSTRATION REACTOR PROGRAMME

INCLUDING the first two proposals formally submitted in response to the third invitation issued by the Commission for public and private organisations to participate in its Power Demonstration Reactor Programme, a total of twelve proposals has been received. Under the first invitation issued January, 1955, three proposals were approved as bases for contract negotiations, and two contracts have been signed. Under the second invitation issued in September, 1955, and calling for proposals for small-size nuclear power plants, four of the seven proposals received were approved as bases for contract negotiations. The seven accepted proposals, including those under contract and those on which contracts were being negotiated were :

Organisation and plant location	Type	Principal contractor	Power (electrical, MW)
Power Reactor Development Company, Inc. (Monroe, Mich.)	Fast breeder	P.R.D.C.	100
Yankee Atomic Electric Company (Rowe, Mass.)	Pressurised water ...	Westinghouse Electric Corp.	134
Consumers' Public Power District (Beatrice, Nebr.)...	Sodium graphite ...	Atomics International ...	75
Rural Co-operative Power Association (Elk River, Minn.) ...	Boiling water	A.M.F. Atomics Inc. ...	22
Wolverine Electric Co-operative (Hersey, Mich.)	Aqueous homogeneous	Foster-Wheeler Corp. ...	10
Chugach Electric Assoc. Inc., and Nuclear Development Corp. of America (Anchorage, Alaska)	Sodium, heavy water...	Nuclear Development Corp. of America	10
City of Piqua, Ohio	Organic moderated ...	Atomics International ...	12

In expanding the Power Demonstration Reactor Programme on January 7 by issuing a third invitation for proposals to develop, design, construct and operate nuclear power plants, the Commission placed no limitations as to types or sizes, and no deadline for submission of proposals other than a requirement that plant construction be completed by certain fixed dates. The completion date was originally set as not later than June 30, 1962, and this still applies for all kinds of reactors except one. For reactors using a fluid-fuel system, the completion date was extended until at least June 30, 1963. This extension was made necessary by unforeseeable delays in the Commission's research and development programme expected to produce basic data for reactors of this kind. The Commission expressed a special interest in reactors fuelled by (*a*) natural uranium with a heavy water moderator, and (*b*) aqueous solutions or slurries of either uranium or uranium- and thorium-bearing materials. Should industry not make acceptable proposals on these kinds of reactors, the Commission will request Congressional authority and funds to initiate them as Government projects. Similarly, and on the same conditions, the Commission expected from time to time to specify other types of reactors as ready for construction when technological progress appeared to warrant such announcement. The assistance to be provided by the Commission under the third invitation is of three general kinds : (*a*) waiver of established charges for the use of source and special nuclear materials over a specified period of time ; (*b*) performance at no charge, or at a reduced charge in Commission laboratories, of mutually agreed-upon research and development not reasonably available elsewhere, and (*c*) support of research and development required to advance the technology of projects which promise to make a significant contribution toward achieving economic, abundant and safe nuclear power.

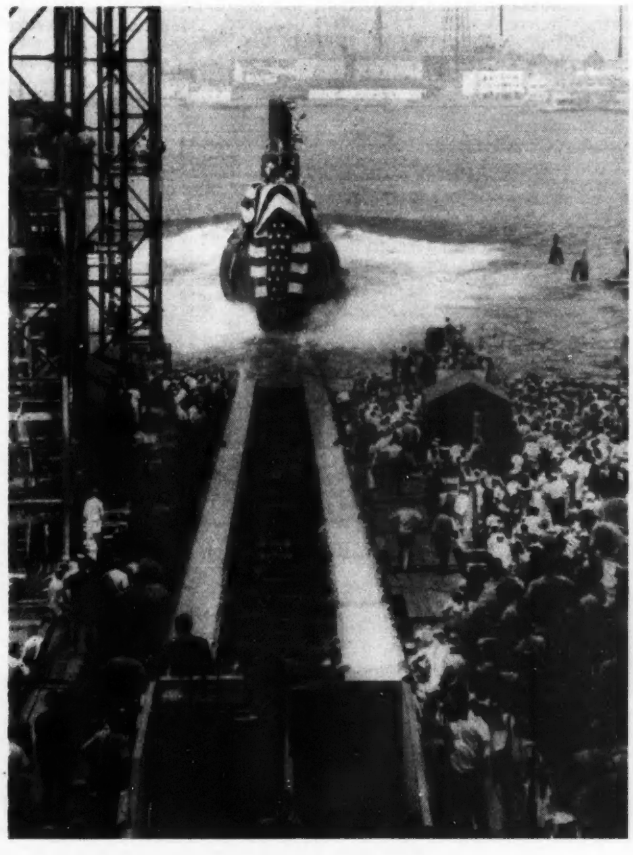
On April 30, the Florida Nuclear Power Group, consisting of the Florida Power Corporation, the Florida Power and Light Company, and the Tampa Electric Company, submitted a proposal in response to the third invitation. The proposal contemplates constructing in west-central Florida a natural - uranium - fuelled, heavy - water - moderated, gas-cooled reactor of 136MW of electricity. On May 15, the Northern States Power Company, a utility company operating in Minnesota, Wisconsin, North and South Dakota, proposed a boiling water reactor power plant designed to generate 66MW of electricity. A number of other midwest utilities indicated they would contribute to part of the cost of research and development for this project.

The contract executed by the Power Reactor Development Company (P.R.D.C.) and the Commission on March 26 was the second one for a reactor proposed in response to the Commission's first invitation under the Power Demonstration Reactor Programme. By this contract, the Commission undertakes to perform research and development at a cost to the Commission no greater than 4,450,000 dollars and to waive its normal use charges on the special nuclear material fuel for five years after the issue of an operating licence. In return, the Detroit company is to provide to the Commission complete information on the construction and operation of its fast breeder reactor at Monroe, Michigan, rated at 100,000 electric kilowatts. In an agreement signed at the same time, the Commission undertook to reprocess the company's spent fuel and blanket material until commercial facilities became available to provide this service at a reasonable price. Construction of the steel reactor building began during this reporting period, on the 915-acre site near Monroe, Michigan. Site development and foundation work were under way. The Yankee Atomic Electric Company, of Boston, Massachusetts, continued research and development work on the 134MW of electricity pressurised-water reactor which it plans to build at Rowe, Massachusetts, by 1960. Contract negotiations continued during this reporting period with the Consumers' Public Power District, Columbus, Nebraska, for its proposed 75MW of electricity sodium-graphite nuclear power plant. In connection with the joint proposal of the Chugach Electric Association of Anchorage, Alaska, and the Nuclear Development Corporation of America (NDA), White Plains, New York, the Commission contracted with NDA for research, development and preliminary design work at an estimated cost of 2,200,000 dollars to demonstrate the feasibility of a liquid sodium-cooled, heavy-water-moderated reactor system. This work looked toward the construction and operation of a nuclear electric plant at Anchorage, Alaska, under a three-party agreement now being negotiated among the Nuclear Development Corporation, the Chugach Association, and the Commission. The contract with NDA covers work under the first of three phases. Negotiations continued on a contract with Chugach and NDA which would cover the remaining phases of the project—final development and engineering design; and construction, start-up and operation.

MARITIME PROPULSION REACTORS

The Commission and the Maritime Administration established by a memorandum of understanding their administrative arrangements for carrying out a co-operative programme for the construction of the first nuclear-powered merchant ship and also for a longer-range development programme aimed at achieving economically competitive nuclear propulsion for merchant ships. A contract was executed on April 8 with the Babcock and Wilcox Company, of New York, for the design and construction of the nuclear propulsion plant for the first nuclear-powered merchant ship. The contract stipulates that for a fixed price of about 10,000,000 dollars, Babcock and Wilcox will provide the basic propulsion system, including the reactor and components of the steam plant and auxiliary systems. The remainder of the Commission's responsibilities in this project, which include supplying the containment vessel, shielding, and related items for the reactor, and the installation of the propulsion system, were not included in the present contract and are to be provided by appropriate contractors at a later date. The Maritime Administration awarded a contract to George G. Sharp, Incorporated, New York, to act as design agent for the ship itself. The company engaged the Walter Kidde Nuclear Laboratories as consultant on the nuclear phases of design. A joint Shipyard Survey Board of the Commission and the Maritime Administration completed its review of the facilities and personnel at shipyards interested in constructing the first ship and qualified to do so.

The survey will give a basis for selecting a yard with which to negotiate a fixed-price contract.



Launching of the U.S.S. "Seawolf" at Groton, Connecticut

Work started during this reporting period on resolving the many unique operating requirements associated with the entry of nuclear-powered ships into foreign and domestic commerce. The vessel now being planned is considered a forerunner of an eventual privately owned and operated American nuclear-powered merchant navy. As part of this programme, co-operative efforts were started with the U.S. Coast and Geodetic Survey for harbour survey work, with the U.S. Coast Guard for establishing operating and design and construction codes and regulations, and with the U.S. Public Health Service to ascertain appropriate health and safety regulations. In addition, marine insurance underwriters were studying anticipated insurance needs. Arthur D. Little Incorporated, of Cambridge, Massachusetts, undertook to analyse the health physics and safety aspects associated with operating nuclear-powered merchant ships, and the Ralph M. Parsons Company, of Los Angeles, was investigating shore and fuel handling facilities and preparing recommendations pertaining to these facilities as they relate to nuclear ships.

Development work also continued on an intermediate and long-range programme leading to competitive nuclear power plants for merchant ships. Preliminary design feasibility studies were completed on the following concepts : organic-cooled and moderated ; boiling water and three gas-cooled systems with closed-cycle turbines ; two helium-graphite systems and a carbon dioxide hydride-moderated system. A consideration of these studies is expected to define a long-range effort on concepts that offer the maximum possibility of producing competitive power. A contract was awarded to the Westinghouse Electric Corporation for the study of a super-critical water reactor, which would operate at extremely high pressures and temperatures. The American Radiator and Standard Sanitary Corporation, of Redwood City, California, with the Stanford Research Institute, of Menlo Park, California, as a sub-contractor, was selected to study the possible applications of nuclear energy within the next decade to the entire field of merchant ship propulsion, taking into consideration evolutionary trends of both conventional and nuclear systems. In connection with this development work, private industry showed increased interest in the role nuclear energy will play in the future merchant navy. Several ship-operating companies indicated a willingness to participate with the Government in a co-operative nuclear shipbuilding programme.

Military Reactors

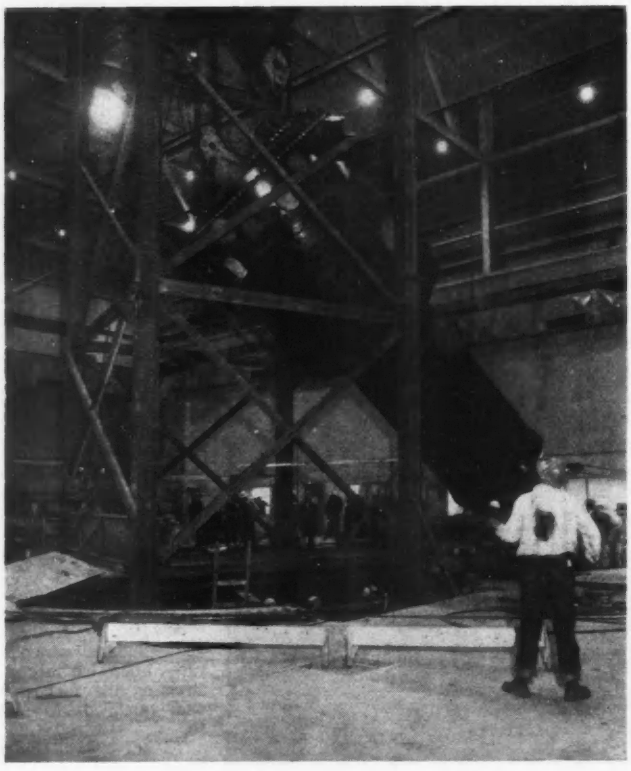
The Submarine Thermal Reactor plant at the National Reactor Testing Station continued operating during this reporting period to develop and test improved reactor devices and to train naval personnel. The submarine U.S.S. " Nautilus " was refuelled at the Electric Boat Division of the General Dynamics Corporation, after travelling 62,560 miles, 36,498 of which were fully submerged. To duplicate this performance a conventionally powered submarine of the same size would have required more than 2,000,000 gallons of diesel fuel. The used core was shipped to the National Reactor Testing Station for examination. The " Nautilus " put to sea again on April 11. In May, while travelling to the Pacific to participate in fleet activities, the " Nautilus " travelled the 3049 miles from Panama to San Diego completely submerged. This is believed to be the longest distance any ship has ever travelled under water without surfacing. An average speed of over 19 knots was maintained.

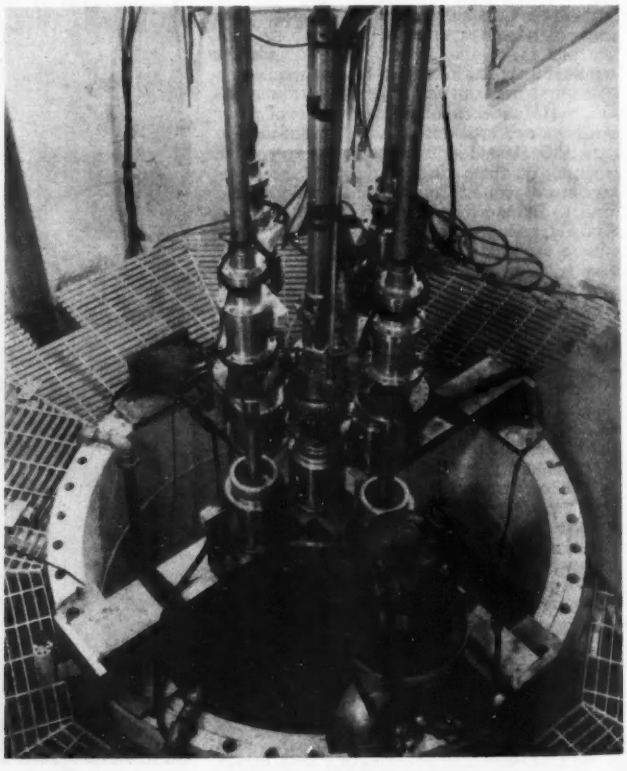
In March the Commission shut down the Submarine Intermediate Reactor land-based prototype of the U.S.S. " Seawolf " propulsion plant at West Milton, New York. This action resulted from the U.S. Navy's plan not to install sodium-cooled reactor propulsion systems in additional naval vessels and from the fact that the experiments conducted for the " Seawolf " prototype plant will be retained intact for future use in experimental operation of prototypes for other naval power plants. Following the decision to shut down this reactor, the contract with the Niagara Mohawk Power Corporation for the sale of electric power produced by it was terminated on March 21. The U.S.S. " Seawolf " powered by the " S2G " reactor plant, put to sea on January 21 for her first sea trials. On February 2, she completed her builder's trials, and in March the Navy Department conducted Board of Inspection and Survey trials. As a result of these trials, the Board recommended that the " Seawolf " be accepted for restricted service and that the sodium plant be replaced with a pressurised water reactor plant of the " Nautilus " type. The " Seawolf " was commissioned on March 30 at Groton, Connecticut.

Design and development work on the Submarine Advanced Reactor propulsion plant (S4G) was continued at the Knolls Atomic Power Laboratory at Schenectady, New York, by General Electric. The construction of the prototype plant (S3G) continued at West Milton, New York. A section of a submarine hull was erected to house the prototype reactor compartment and engine-room. Design and development work continued at the Bettis Laboratory in Pittsburgh on a nuclear propulsion plant for a cruiser. This will be the first United States naval surface ship to be propelled by nuclear power. The ship has been named the " Long Beach " by the Secretary of the Navy, and will be built at the Quincy shipyard of the Bethlehem Shipbuilding Division. In February, the Commission assigned to the Knolls Atomic Power Laboratory a project for developing a pressurised water nuclear propulsion plant for use in a surface vessel of the destroyer category. The laboratory contracted with the Shipbuilding Division of the Bethlehem Steel Company for machinery arrangement and propulsion plant design work.

The U.S. Army Package Power Reactor, a prototype of a pressurised water stationary nuclear power plant developed by the Commission for the Department of Defense, achieved criticality on April 8 at the U.S. Army Engineer Center in Fort Belvoir, Virginia. The details of design of the reactor are unclassified, which means that industry has complete access to its technology and can draw upon it for the development of commercial plants for use in this country and abroad.

The Commission negotiated a contract with the Aerojet-General Corporation of Azusa, California, for the design, fabrication and initial operation of the Gas-Cooled Reactor Experiment (GCRE) at the National Reactor Testing Station. This experiment was intended to develop engineering data and to provide experience for the design and construction of gas-cooled reactors to meet military needs and possible civilian requirements for small power stations. The contractor completed the preliminary design

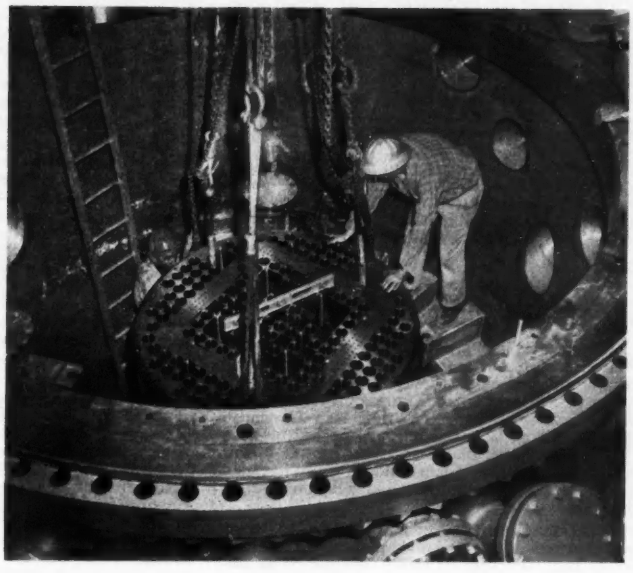




(Left) 75-ton reactor vessel being erected as part of the Engineering Test Reactor at the National Reactor Testing Station in Idaho. (Right) Top of reactor tank with control rod drives of Special Power Excursion Reactor Test Unit in Idaho

experiment and continued to perform supporting research and development. Four gas-cooled loops at different facilities, which will serve to screen and test GCRE components, were in various stages of completion. The General Motors Corporation completed an engineering analysis of a nuclear-powered overland logistical cargo carrier. Gilbert Associates, Incorporated, of Reading, Pennsylvania, completed a preliminary design study of a 20MW (electrical) power station suitable for overseas installations. The Raytheon Manufacturing Company, of Waltham, Massachusetts, completed a conceptual design of a liquid-metal-fuel package reactor. The contract was extended at no cost to the Commission to permit additional experiments aimed at proving the feasibility of the design.

Reactor experiments relative to nuclear operation of turbo-jet engines continued at the National Reactor Testing Station performed by the General Electric Company under contract to the Commission. The construction of facilities at the Connecticut Aircraft Nuclear Engine Laboratory proceeded satisfactorily and some parts were occupied. This laboratory is being built at Middletown, Connecticut, by the U.S. Air Force, and will be used for research and development work for the Air Force and the Commission. It will be operated by the Pratt and Whitney Aircraft Division of the United Aircraft Corporation, East Hartford, Connecticut, under contract to the Air Force and the Commission.



Grid plate being lowered into the pressure vessel of the Engineering Test Reactor at Arco, Idaho

General Engineering and Development

The construction of the Engineering Test Reactor (ETR) at the National Reactor Testing Station continued during the reporting period. Operating at 175MW, the ETR will provide a flux of 4×10^{14} thermal energy neutrons and $1{\cdot}5\times10^{15}$ neutrons above thermal energy. The reactor will have larger experimental spaces than earlier test reactors, most of them being incorporated in the fuel section of the core. The ETR will be used primarily in the Commission's reactor development programme. Kaiser Engineers, a division of the Henry J. Kaiser Company, is responsible for the architect-engineering work, for the overall design based on conceptual design studies by the Phillips Petroleum Company and for the construction of the reactor. The nuclear design of the reactor core and facilities within the tank was by the Atomic Power Equipment Department of the General Electric Company under contract to Kaiser. The reactor will be operated by the Phillips Petroleum Company. An ETR critical facility was completed on schedule at the N.R.T.S. and achieved criticality in May. It will yield important operating information on experiments before actual ETR irradiations.

Charges for all Materials Testing Reactor irradiations were reduced 12 per cent, effective January 7. The reduction reflected efforts by the Phillips Petroleum Company, the operating contractor, to reduce the costs of operation by the more efficient utilisation of the reactor, equipment and manpower.

The Commission continued its programme to develop fuel elements using uranium enriched to 20 per cent in uranium 235, primarily for research reactors of other countries. During this reporting period two uranium-aluminium alloy elements were fabricated by the Oak Ridge National Laboratory and four by Babcock and Wilcox. The elements then were irradiated in the Materials Testing Reactor, and none of the inspected elements has yet shown any evidence of damage. Negotiations were completed for procuring from Babcock and Wilcox a full core loading of 20 per cent enriched uranium 235 fuel elements for the operation of the Materials Testing Reactor. The results from operation with these elements will be compared with the results obtained previously with highly enriched elements.

Irradiation of four plutonium fuel elements and three plutonium fuel shim (movable) elements, fabricated from plutonium-aluminium alloy, was started in the Materials Testing Reactor to produce for research multi-gramme quantities of higher plutonium isotopes and trans-plutonium isotopes and to determine the damage caused by irradiation. The fuel shim elements will be irradiated for two years ; the fuel elements for about 150 days. The results to date have revealed no evidence of radiation damage, distortion or fission breaks. Additional plutonium fuel elements were being prepared at the Oak Ridge National Laboratory and the Los Alamos Scientific Laboratory, and the feasibility of operating the Materials Testing Reactor with a full core loading of plutonium elements was being investigated.

Transient testing (i.e. testing the behaviour of reactors when subjected to variations in the rate of neutron production) continued at the National Reactor Testing Station on the Special Power Excursion Reactor Test (SPERT–1), a water-moderated reactor in an unpressurised tank which became critical in July, 1955. Design work was completed on SPERT–2, and construction continued on SPERT–3. These reactors are intended to yield safety information on the operation of medium-pressure and high-pressure water reactors, respectively, and were scheduled for completion in 1958. Transient tests continued also with the Kinetic Experiment on Water Boilers (KEWB–1), a homogeneous water-boiler reactor which is operated for the Commission by Atomics International at Santa Susana.

After more than 1000 successful operations, a small fast-neutron critical assembly known as Godiva was dismantled and retired at the Los Alamos Scientific Laboratory after an accidental excursion on February 12 which disrupted the enriched uranium core and damaged support members. Godiva was so named because it was an unshielded, unmoderated spherical mass of uranium 235. Godiva was operated by remote controls situated about a quarter of a mile away, in order to prevent accidental exposure of personnel to radioactivity during routine tests. This practice has proved valuable in that, under abnormal conditions, such as this incident, no personnel were exposed to released radioactivity. At the time of the accident the assembly was being used as a source of neutrons for instantaneous irradiation of experimental reactor fuels. The purpose of the experiment was to determine the behaviour of this material after exposure to a sudden wave of neutrons. The thermal shock which caused the damage was the result of a nuclear power surge considerably higher than the expected power level.

Godiva was built about six years ago in order to make experimental investigations of the characteristics of unreflected assemblies of enriched uranium metal. It was modified later to explore chain reaction phenomena just above the prompt critical condition, i.e. the level of criticality in which the reaction is sustained by the neutrons emitted shortly after a fission occurs. It was found that the fast fission bursts produced under these conditions were self-limited by virtue of the thermal expansion of the uranium assembly. A pulse of gamma and neutron radiation accompanies the fission burst. This radiation pulse was found to be extremely valuable in biomedical studies of radiation effects, evaluation of radiation damage to material, and calibration of measurements made in connection with nuclear bomb tests. The Godiva device therefore was adapted as a radiation source for such studies. As the work continued it was recognised that many improvements in convenience and control could be made, and replacement equipment was under design at the time of the accidental excursion. The new equipment was completed and placed in operation in June.

One large factor that may help to reduce the costs of electric power generated by nuclear reactors is a cheaper method of removing fission products from irradiated fuel elements and blanket materials. In an effort to reduce fuel cycle costs, the Commission continued its varied efforts to improve the methods for the chemical processing of irradiated fuel elements. In this field, work continued on the development of processes which will permit the dissolution and preliminary treatment of fuels of widely differing chemistries in existing processing plants. This work was directed toward reducing the processing costs in the period before private enterprise enters this field. Two promising processes are the "Darex" and "Zircex." "Darex," under development by the Oak Ridge National Laboratory and Phillips Petroleum at the Idaho Chemical Processing Plant, involves treatment of stainless steel bearing fuels with mixtures of nitric acid and hydrochloric acid. "Zircex," which is being developed by the Oak Ridge National Laboratory, involves anhydrous hydrochlorination of zirconium-bearing fuels under conditions such that the zirconium can be separated as a volatile product. In both cases, the uranium stream can be converted to an aqueous uranyl-nitrate solution and fed to conventional liquid-liquid extraction systems.

Considerable progress was made on the volatility process development studies under way at the Argonne and Oak Ridge National Laboratories. The Argonne National Laboratory demonstrated on a pilot plant scale that single-cycle volatility processing will decontaminate irradiated natural uranium sufficiently so that the residual radioactivity is less than that of unirradiated natural uranium. Investigations continued on a volatility process for separating plutonium from fission product residues. The construction of the Oak Ridge volatility pilot plant involving a different processing approach was virtually completed.

Argonne worked on a process for separating and purifying irradiated uranium by dissolving fuel in molten zinc, followed by the formation and separation of an intermetallic uranium-zinc compound. Preliminary results indicated that this process for limited decontamination may be suitable for use in integrated facilities which contain an operating reactor, a chemical processing plant and facilities for remote fuel-element refabrication. A possible advantage was that this process may permit the separating of certain fission products which most pyrometallurgical methods to not remove, i.e. those elements that are less electropositive than uranium.

(To be continued)

Personal and Business

Appointments

MR. F. B. RIDER has been appointed sales manager of Thermocontrol Installations Company, Ltd.

A. LAWRENCE AND CO. (MACHINE TOOLS), Ltd., has announced that Mr. L. G. Walter has joined the company.

MR. F. E. J. HOWARD, A.M.I.Mech.E., has been appointed a director of the Globe Pneumatic Engineering Company, Ltd.

THE BRITISH TRANSPORT COMMISSION has announced the appointment of Mr. Frank Grundy as chief traffic officer, British Railways Central Staff.

ACHESON INDUSTRIES (EUROPE), Ltd., has announced that Mr. S. Mackenzie-Owen has been appointed unit manager of Acheson Colloiden N.V., Scheenda, Netherlands.

THE BRITISH ASSOCIATION OF MACHINE TOOL MERCHANTS has announced that Mr. Herbert Widdowson has been elected president and Mr. S. Plastock, vice-president.

MR. C. J. STADDON, A.M.I.E.E., has relinquished his appointment with McLellan and Partners to join John Miles and Partners (London), Ltd., in its electrical engineering department.

MR. EDWARD BURRETT has been appointed consultant designer to Galitzine and Partners, Ltd., and has also joined the board of directors of its associated company, P.R.O. Service, Ltd.

MR. JOHN DYER has resigned from the position of public relations officer for E.M.I. Electronics, Ltd., in order to join the staff of the British Electrical and Allied Manufacturers' Association as technical editor of the *Beama Journal*.

THE GENERAL ELECTRIC COMPANY, Ltd., announces the following appointments :—Mr. T. W. Heather, Mr. A. L. G. Lindley and Mr. R. E. Robinson have been appointed assistant managing directors ; Mr. D. G. W. Acworth and Mr. W. J. Bird have been appointed directors.

Business Announcements

THE FREE PISTON ENGINE COMPANY, Ltd., states that its head office has been moved to Feltham, Middlesex.

CHEMINDUS PLASTICS, Ltd., states that its sales and administrative offices are now located at 26, Progress Way, Purley Way, Croydon, Surrey (telephone, Croydon 9351).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has opened a new depot at 511, Roumelia Lane, Boscombe, Hants (telephone, Boscombe 36223). The depot will be in the charge of Mr. A. J. Pearson.

GARRINGTONS, Ltd., Bromsgrove, Worcs, states that the development, production and sales of Garrington constant velocity joints will in future be solely undertaken by the B.R.D. Company, Ltd., Aldridge, Walsall.

PLENTY AND SON, Ltd., Eagle Iron Works, Newbury, Berks, states that it has purchased a new factory site with existing buildings at Shaw, Berkshire, to which will be moved the manufacture of its smaller pumps, filters, and " Impelator " mixing machines.

CONCRETE, Ltd., states that its northern organisation has been formed into a separate company, Concrete (Northern), Ltd. The directors are Mr. T. S. Lucas, chairman ; Mr. T. H. G. Mathews, managing director, and Mr. A. E. S. Jackson, Mr. W. Dickinson and Mr. L. Wright.

JAMES HODGKINSON (SALFORD), Ltd., has acquired a controlling interest in Bennis Combustion, Ltd., and its subsidiaries, the Saxon Engineering Company, Ltd. and Bennis Mechanizations, Ltd. Three Hodgkinson directors, Mr. N. C. Crighton, A.M.I.Mech.E., Mr. E. L. Hollinshead and Mr. J. S. Hodge, have been appointed to the board of Bennis Combustion, Ltd. The trading of these companies will continue under their own names.

Contracts

CONSTRUCTORS JOHN BROWN, Ltd., has received a contract for the construction of a natural gas pipeline system in Lower Austria by Niogas, Niederosterreich Gasvertriebs A.G. The pipeline system will cover a total of 160 miles, and Constructors John Brown, Ltd., will use the technical services of its American associates, Williams Brothers of Tulsa, Oklahoma. Austrian sub-contractors will carry out a considerable part of the work and Austrian labour and equipment will be used. The pipeline is to carry natural gas of high calorific value from sources at Bockfliess, just north of Vienna, and Schwechat, south-east of the city, to two areas. A western section will serve the Danube basin above Vienna and such centres as St. Polten and Krems. A southern section will cover places such as Wiener Neustadt and will extend as far as the Semmering Pass, near the boundary of Lower Austria and Steiermark. The pipeline will range from 12in to 6in in diameter with a high proportion of 12in and 10in sections. Gas, which will be cleaned and dried before being supplied, will flow through the pipeline at a maximum pressure of 900 lb per square inch. The value of the contract is £1,500,000.

GLENFIELD AND KENNEDY, Ltd., Kilmarnock, has secured an order worth some £450,000 from the Sydney Metropolitan Water, Sewerage and Drainage Board, N.S.W., Australia, for the design and supply of all the spillway crest control gates for the Board's Warragamba dam project. The construction of this large dam, which has a maximum hydraulic height of about 333ft and a length at road level of approximately 1100ft, will augment the supply of water to the City of Sydney, generate 50MW of electricity, and provide a limited measure of flood control. The crest gates will comprise a drum gate of 90ft span by 25ft deep, and four radial gates, each of 40ft span by 42ft deep.

Miscellanea

INSTITUTE OF PETROLEUM.—The Institute of Petroleum, which was founded as the Institution of Petroleum Technologists in 1913, has had a number of homes. However, on Thursday, November 28, its permanent headquarters at 61, New Cavendish Street, London, W.1, was officially opened by Lord Mills, the Minister of Power. The Institute is now accommodated in an Adam building, which has been reconstructed for the purpose, and is the third Adam house to be so occupied.

OIL-RESISTANT TRANSMISSION BELT.—A recent addition to the range of plastic belts made by R. and J. Dick, Ltd., Greenhead Works, Glasgow, is an oil-resistant belt, which is stated to retain a high coefficient of friction under the oiliest running conditions, as well as being resistant to stretching and the effects of heat. Known as the " Dixon-Suplex," it is particularly suited to high speed drives up to 10,000ft per minute on such equipments as machine tools and textile machines where small diameter pulleys and short centres are involved.

SEVENTY-FIFTH ANNIVERSARY.—In September of this year, Eisenwerk Wülfel celebrated the seventy-fifth anniversary of its existence as a joint stock company, originally under the style of Hannoversche Messing-und Eisenwerke. Concentrating on the production of power transmission equipment since 1893, and taking up the manufacture of gear units in 1927, the firm has established a worldwide reputation in those fields. In order to mark the anniversary, a well-illustrated brochure has been published in German, English and French.

PERMANENT PATTERN MAKING COMPOUND.—A material known as " Titanite," which is now available from the Constructional Engineering Company, Ltd., Charles Henry Street, Birmingham, 12, has a number of applications for the making of permanent foundry patterns, die-sinking models and moulds for plastics. The material is supplied in the form of a fine grain stone powder and a liquid which are mixed together in correct proportions and poured into or over the master moulds, patterns or formers. The mixture sets to a marble-like hardness in a few hours with exact reproduction of detail from the master.

FILMS ON STAINLESS STEEL.—Two 16mm Kodachrome colour films, are now available on loan, free of charge, from Firth-Vickers Stainless Steels, Ltd., Staybrite Works, Sheffield, 9. Lasting about half-an-hour each, the films are entitled, respectively, " The Manipulation of Corrosion and Heat-Resisting Steels " and " Where ' Staybrite ' Steels are Made." The latter shows bar, sheet, strip and castings in production, and indicates some of their industrial and domestic uses. The first film, after reviewing some applications, offers hints to fabricators. Forming, machining, welding and cleaning processes of various kinds are dealt with.

GAS LIQUEFYING PLANT.—A new version is now available of the gas refrigerating machine supplied by Philips Electrical, Ltd. The liquefaction of the gas takes place in a closed space and therefore gases other than air can be handled. Temperatures down to —200 deg. Cent. are achieved using either hydrogen or helium as a refrigerant, but the machine is not intended to handle inflammable gases. Moisture and carbon dioxide are removed by solidification on a precooler, and defrosting of this with hot air requires about one hour after sixteen to twenty hours' operation ; production commences within fifteen minutes of starting up. The P.W.7000, like the previous liquid air plants, is electrically driven.

VEHICLE STATISTICS.—The November *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, Ltd., records that third quarter car production in 1957, at 218,035, was the highest for any year. Car exports for September, 33,460 cars out of 96,762 produced, were the highest for any year, as also was the total for nine months, 311,745 out of 606,607. For the nine months the value of car exports was higher than last year in all major markets except Australia (£9,500,000 instead of £13,400,000), the Netherlands and British Malaya. Exports of commercial vehicles dropped, totalling £64,500,000 to September, 1957, against £66,800,000 to September, 1956.

OVERHEAD TRAVELLING CRANES.—An improved range of overhead travelling cranes, introduced by the Vaughan Crane Company, Ltd., of Manchester, covers capacities from 1 to 20 tons, and they are all of three-motion design, arranged for control from a driver's cage or from the floor. Each of the crane motion drives embodies magnetic eddy current couplings, which permits a 35 : 1 speed range for precision handling duties involving great accuracy. The new squirrel-cage B.T.H./Vaughan " Varislip " motors fitted have magnetic couplings built into them. The hoist and lower motion is now controlled by a special equipment designed by Metropolitan-Vickers, embodying the flux resetting amplifier, giving fully controlled hoisting and lowering speeds which are predetermined, irrespective of the load on the hook.

LUBRICANTS FOR NUCLEAR POWER STATIONS.—Contracts have been placed with Wakefield-Dick Industrial Oils, Ltd., by the Central Electricity Authority and the U.K. Atomic Energy Authority for the lubrication of the new power stations at Berkeley and Chapelcross. In announcing this, the company points out that the greater part of a nuclear power station is " inactive," or not seriously subject to radiation. It is only in the " active " portion, within the reactor itself and in its immediate vicinity, that the degradation of lubricants is a serious problem. Fission produces four types of radiation, α, β and γ rays and neutrons. The first two are generally absorbed by the structure and shielding of the reactor. γ rays and neutrons, however, can thicken lubricating oils to a point at which they are unserviceable, and greases can become hard solids. The increase in viscosity appears to occur in two stages. In the first the oil may be only slightly thickened, while grease may actually become softer. In the second stage the increase in viscosity and the solidification proceed more rapidly. There is no certain way of forecasting from the behaviour of one material what is likely to happen to another when subjected to radiation, and research on lubricants for nuclear power stations involves the irradiation of samples of many different products. Certain petroleum-based lubricants have been shown to resist the thickening effect more strongly than others, while certain materials not of petroleum origin have shown promise.

NYLON CHUTES FOR BRICKWORKS.—It is claimed that, after lengthy trials, a brickworks near Exeter is obtaining successful results with nylon chutes for conveying clay from the feed hoppers to the presses. The account we have received from British Nylon Spinners, Ltd., states that only a measured quantity of clay is fed at a time, and that the progress of the material through the chute therefore takes place in jerks. The clay falling into the top end of the chute thus tends to compress the clay lower down. It is said that conventional tarred-canvas chutes are so rigid that this action leads to blockage. Attempts to overcome this difficulty by using plain canvas failed because the fabric soon rotted. Trials with nylon are reported to have shown that the resilience of this material prevents blockage, since chutes made of it merely bulge slightly under the internal pressure. The most successful chute is stated to have been made of nylon staple fabric weighing half as much as the normal tarred canvas. This nylon is said now to be used on all the presses in the brickworks. We are told that laboratory tests on 2in strips of the cloth indicate : (*a*) a breaking load of about 560 lb in the warp and 480 lb in the weft, and (*b*) a tearing strength of about 120 lb in the warp and 115 lb in the weft. The cost of a nylon chute is given as about 25 per cent more than one in tarred canvas, but this is thought to be offset by the better endurance. The case is cited of a trial chute that has lasted for two years (the reported maximum life of a tarred-canvas chute), and is not only still in good condition, but is expected to last substantially longer than the additional six months required for parity of cost with tarred canvas.

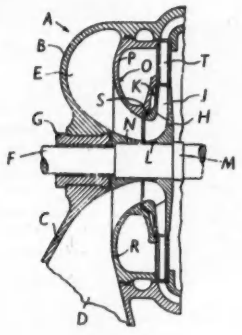
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

COMPRESSORS AND BLOWERS

785,419. March 21, 1956.—RADIAL-FLOW COMPRESSORS, Sulzer Freres, Societe Anonyme, Winterthur, Switzerland.

The invention relates to single or multi-stage, radial-flow compressors for compressible fluids and provides an improved method of manufacturing a number of such compressors having different characteristics. The drawing shows a section through a single-stage, radial-flow compressor, or the first stage of a multi-stage, radial-flow compressor, provided with a shrouded rotor and a corresponding insertion. The housing *A* of the compressor consists of two halves *B* and *C* and includes an inlet pipe *D* leading to an inlet channel *E*. The compressor shaft *F* is supported at one end in a bearing *G*, the bearing at the



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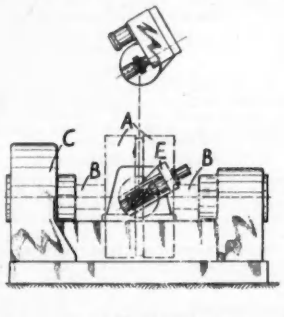
other end not being shown in the drawing. In a multi-stage machine the subsequent stages would be added to the right of the parts shown in the drawing. In the case of a single-stage machine an outlet channel would be added to the right of the parts shown in the drawings. In the construction shown the rotor *H* is provided with blades *J* and is closed by a shroud plate *K*, the rotor and an intermediate sleeve *L* being firmly clamped between a collar *M* on the shaft and a clamping ring *N*. A stationary removable insertion *O* is provided in the housing, consisting of two halves *P* and *R*, the insertion being so shaped that a part of it lies adjacent to the shroud plate *K* and another part of it bounds part of the inlet channel *E*. A labyrinth seal is provided between these parts as indicated at *S*. A removable stationary diffuser *T* is inserted in the housing around the periphery of the rotor. A modified construction for an open-sided rotor is also shown in the specification.—*October* 30, 1957.

MACHINE TOOLS

784,958. August 10, 1955.—GEAR HOBBING MACHINES, Craven Brothers (Manchester), Ltd., Vauxhall Works, Reddish, Stockport, Cheshire. (*Inventor: Alfred Kurt Thomas.*)

The invention relates to gear hobbing machines of the type in which the gears which are being hobbed are mounted on a horizontal axis and revolved at



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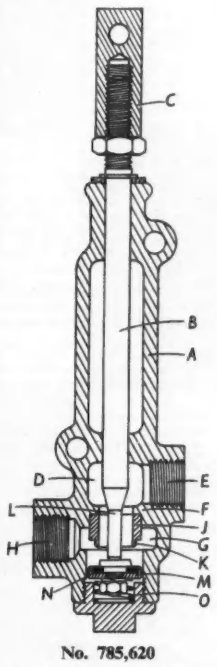
the normal slow speed requisite for hobbing and at high speeds for a gear shaving operation. The running of what is termed the work spindle at high speeds for the gear shaving operation jeopardises the high degree of accuracy called for in the gear hobbing operation. The object of the invention is to provide an improved construction of gear hobbing machine which obviates the disadvantage of present constructions. A gear hobbing machine is provided having the workpiece axis horizontal, the workpiece being driven through one headstock at the slow speed requisite for hobbing and it is disconnected from the drive in this headstock and connected to a drive through the other headstock for the high-speed shaving operation. In this way the drives for hobbing and shaving are kept separate and distinct and avoid damage to the normal hobbing drive which might occur if it is driven at high speed for shaving. Referring to the drawing, the upper view shows the shaving head, which replaces the normal hob slide for the shaving operation. The workpiece *A* upon its spindle *B* is driven from or through one headstock *C* at the slow speed requisite for hobbing. It is disconnected from this drive and connected to a drive from or through the other headstock for the high-speed shaving operation. In this way the drives for hobbing and shaving are kept separate and distinct. When shaving, the hob slide *E* is replaced by the shaving head shown in the upper view.—*October* 16, 1957.

ROAD TRANSPORT

785,620. March 8, 1955.—FLUID PRESSURE BRAKING SYSTEMS FOR ROAD VEHICLES, The Westinghouse Brake and Signal Company, Ltd., and Arthur William Simmons, both of 82, York Way, King's Cross, London, N.1, England.

The invention relates to fluid pressure braking systems for road vehicles of the kind in which brakes are operated by compressed air or vacuum under the control of a pedal-operated control valve. According to the invention, an additional valve is provided interposed in the exhaust passage of the pedal-operated valve and controlling communication between this passage and the external atmosphere. This additional valve is normally open and arranged to be operated to its closed position by the driver of the vehicle so as to close the exhaust passage and thus prevent the release of the air brakes. The vehicle can be stopped on a hill by means of the air brake by operating the pedal-operated control valve. The hand brake may then be applied and the driver is then able to release his foot brake pedal without releasing the air brakes and has both feet free for the operation of the clutch and accelerator for starting, the air brake being graduated off at will by means of the hand brake lever. Referring to the drawing, it will be seen that the valve comprises a casing or body *A* in which is slidably mounted an operating rod *B*, the end of which, projecting beyond the casing, carries a crosshead *C*. Adjacent to the opposite end of the casing an exhaust chamber *D* is provided communicating with the external atmosphere through a port *E*. An internal partition *F* separates the chamber *D* from a chamber *G* in open communication with the exhaust of the pedal control valve of the braking system through a port *H*. A valve seat member *J* having a seat rib *K* is mounted in the partition *F* and the reduced end *L* of the rod passes through the seat as shown. A valve member *M* in an extension of the chamber *G* is provided with an annular leather or rubber packing *N* and a controlling spring *O*. The crosshead *C* is mechanically coupled in any suitable manner to the hand brake lever, so that when the latter is in its release position the parts of the valve occupy the position shown, the valve member *M* being held off the valve seat rib *K* against the opposing action of the spring *O* by the rod, the end *L* of which engages with the head of a short bolt holding the packing *N* in position in the valve *M*. The position of the operating rod can be adjusted by rotating the crosshead *C* and securing it by a lock nut. It will be evident that under these conditions the exhaust port *H* is in free communication with the atmosphere through the port *E* and the air brakes can be released in the normal manner. When, however, the hand brake lever is moved to a braking position the rod *B* is moved by the crosshead *C* to withdraw the reduced end *L* of rod from engagement with the head of the valve member *M*, which is then free to move into engagement with the valve seat member *J*, the packing *N* seating on the rib *K*, thus cutting off communication between the chambers *D* and *G*, so as to shut off the exhaust port *H* from the atmosphere. The pedal of the air brake control valve can thus be released by the driver without causing release of the air brake, which will remain applied until the additional valve is reopened by releasing the hand brake lever. This release of the air brake can evidently be graduated if necessary by intermittently operating the hand brake lever to its release position. In an alternative arrangement the additional valve may be constituted by a simple hand-operated valve or cock having the means to operate it by hand mounted on the dashboard or other position convenient to the driver.—*October* 30, 1957.



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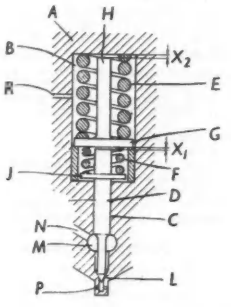
INTERNAL COMBUSTION ENGINES

785,411. January 10, 1956.—INJECTION NOZZLES, Adolph Saurer, Ltd., Arbon, Switzerland.

The invention consists in an injection nozzle for internal combustion engines, with a valve member which, under the action of the fuel pressure, is displaced against the forces of two springs and at the same time releases in two stages the cross-sectional area of flow for the fuel to be injected in such a manner that the valve does not close between the two



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stages. In the specification diagrams the quantity injected related to unit time and the relation between fuel pressure and cross-sectional area of flow are shown. In the design of injection nozzle shown in the drawing the nozzle body *A* has the bore *B* constructed as the spring space and the bore *C* as a guide for the needle *D*. In the bore are housed the heavily pre-stressed main spring *E* and the additional spring *F*, which is considerably weaker by comparison, the spring *E* seeking to force the plate *G* provided with the shank *H* against the upper end of the bush *J*, which encloses the spring *F*, which bears at one end against the plate *G* and presses the needle *D* against its seating *L*. The fuel is conveyed to the cavity *M* through the bore *N* and emerges through the injection holes *P*. Between the needle *D* and the plate *G* and between the shank *H* and the upper end wall of the bore *B* are the distances of lift X_1 and X_2. The bore *R* is the duct for leaking oil. The arrangement operates as follows. In the drawing the nozzle is shown in the closed position. On fuel flowing through the duct *N* into the space *M*, the needle *D* is lifted in opposition to the pressure of the spring *F*, the spring force of which is 30 to 70 per cent of the spring force of the spring *E*, from its seating *L* and forced slightly upwards, until the needle *D*, after travelling through the distance X_1, bears against the underside of the plate *G*. During this first part of the injection and with a short distance of lift of the control member *D* only a small quantity of fuel flows at low pressure out of the injection holes *P*. For overcoming the greater initial stressing force of the strong spring *E*, the fuel pressure in the space *M* must rise to such an extent that there will be a period of time, such as is required for obtaining a sufficiently long period of pre-injection. After this high fuel pressure has been exceeded, the nozzle needle *D* is displaced rapidly upwards. Owing to the flat characteristic of the spring *E* a slight increase in pressure will suffice, until the shank *H* of the plate *G* after travelling through the distance X_2, bears against the upper end wall of the bore *B*. Through this greater lift of the needle *D* the cross-sectional area of flow for the main injection is liberated, this taking place rapidly in consequence of the great pressure fall. Several modified valve designs are also shown in the specification.—*October* 30, 1957.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Dec. 6.—STOKE AND CREWE BRANCH : Crewe Arms Hotel, Crewe, "Modern Railway Signalling," F. W. Young, 7.30 p.m. ★ BRISTOL AND WEST OF ENGLAND BRANCH : Grand Hotel, Broad Street, Bristol, "Earth Leakage Protection," J. A. Robbins, 8 p.m. ★ LIVERPOOL AND DISTRICT BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, 2, Discussion on the Thirteenth Edition I.E.E. Regulations, 7.30 p.m.

BRITISH COMPUTER SOCIETY

Mon., Dec. 16.—Northampton College of Advanced Technology, London, E.C.1, "Parallel Programming : A Study of a New Technique in Digital Computer Programming," S. Gill, 6.15 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Dec. 12.—NORTH WESTERN SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, "Process Heating," M. O'C. Horgan, 6.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Dec. 11.—NORTHERN REGION : Metropole Hotel, Leeds, "The Burning of Difficult Fuels," E. J. MacDonald, 11 a.m.; "Methods of Smoke Measurement and Control," G. Nonhebel, 2.30 p.m.

ENGINEERING METROLOGY ASSOCIATION

Thurs., Dec. 12.—Northampton College of Advanced Technology, St. John Street, London, E.C.1, "Thread Grinding," H. B. Perry, 7 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Dec. 9.—LEEDS CENTRE : Lighting Service Bureau, 24, Aire Street, Leeds, 1, "Turning Day into Night—Some Interesting War-Time Secrets," C. H. Wood, 6.15 p.m.

Tues., Dec. 10.—LEEDS CENTRE : Yorkshire Electricity Board, Ferensway, Hull, "Commercial and Industrial Lighting," J. C. Harcourt, 6.30 p.m.

Mon., Dec. 16.—LIVERPOOL CENTRE : Liverpool Passenger Transport Office, 24, Hatton Garden, Liverpool, 3, "Lighting and Coal Mining," W. E. Mangnall, 6 p.m.

INCORPORATED PLANT ENGINEERS

Wed., Dec. 11.—EAST MIDLANDS BRANCH : Sherwood Room, County Hotel, Theatre Square, Nottingham, "Mechanical Handling," A. E. Holmes, 7 p.m. ★ WESTERN BRANCH : Grand Hotel, Bristol, "Air Compressors," A. H. Bailey, 7.15 p.m.

Thurs., Dec. 12.—GLASGOW BRANCH : Scottish Building Centre, 425/427, Sauchiehall Street, Glasgow, "Electric Arc Welding," J. W. Macfarlane, 7.15 p.m. ★ MERSEYSIDE AND N. WALES BRANCH : Exchange Hotel, Liverpool, Discussion on "Heating and Ventilation," opened by H. S. Crump, 7.15 p.m.

Fri., Dec. 13.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Torque Convertors," A. L. Gattis, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Dec. 11.—LONDON BRANCH : Constitutional Club, Northumberland Avenue, London, W.C.2, Joint Meeting with London Section of Institute of Metals, "Properties of Castings in Copper-Base Alloys," F. Hudson, 7.30 p.m.

Thurs., Dec. 12.—BEDS AND HERTS SECTION : Assembly Room, Town Hall, Luton, "S.-g. Iron—A Versatile Engineering Metal," W. W. Braidwood, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

To-day, Dec. 6.—Grosvenor House, London, W.1, Annual Conversazione, 6.30 p.m.

Wed., Dec. 11.—SCOTTISH SECTION : Small Hall, Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Higher Speed Internal Combustion Machinery for Marine Propulsion," J. Calderwood, 7.30 p.m.

Thurs., Dec. 12.—Memorial Building, 76, Mark Lane, London, E.C.3, "The Trials and Maiden Voyage of the Gas Turbine Ship 'John Sergeant,'" J. J. McMullen, 5.30 p.m.

Mon., Dec. 16.—KINGSTON UPON HULL AND EAST MIDLANDS SECTION : Royal Station Hotel, Kingston upon Hull, "The Trials and Maiden Voyage of the Gas Turbine Ship 'John Sergeant,'" J. J. McMullen, 7.30 p.m.

INSTITUTE OF METALS

Mon., Dec. 9.—SCOTTISH LOCAL SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Recent Developments in Magnesium-Base Alloys," E. F. Emley, 6.30 p.m.

Mon. and Tues., Dec. 9 *and* 10.—Atomic Energy Research Establishment, Harwell, Symposium on "Vacancies and other Point Defects in Metals and Alloys."

Wed., Dec. 11.—LONDON LOCAL SECTION : Constitutional Club, Northumberland Avenue, London, W.C.2, Joint Meeting with the London Branch of Institute of British Foundrymen, "Properties of Castings," F. Hudson, 7.30 p.m.

INSTITUTE OF PHYSICS

To-day, Dec. 6.—LIVERPOOL AND NORTH WALES BRANCH : Department of Electrical Engineering, The University, Liverpool, "Cerenkov Radiation," J. V. Jelley, 7 p.m. ★ SOUTH WALES BRANCH : Physics Department, University College of South Wales and Monmouthshire, Cardiff, Branch Annual General Meeting, "Microwave Triodes," M. R. Gavin, 5.15 p.m. ★ NON-DESTRUCTIVE TESTING GROUP : 47, Belgrave Square, London, S.W.1, "Structural Imperfections in Metals and their Effect on Mechanical Properties," N. F. Mott, 6 p.m.

Tues., Dec. 10.—ELECTRONICS GROUP : 47, Belgrave Square, London, S.W.1, "Infra-Red and Microwave Modulators Using Free Carriers in Germanium," A. F. Gibson, 5.30 p.m.

Wed., Dec. 11.—LONDON AND HOME COUNTIES BRANCH : 47, Belgrave Square, London, S.W.1, "Irregularities and Movements in the Ionosphere," B. H. Briggs, 6 p.m. ★ SCOTTISH BRANCH : Royal Philosophical Society of Glasgow, 207, Bath Street, Glasgow, Joint Lecture with Royal Philosophical Society of Glasgow, "Lord Kelvin," P. I. Dee, 7 p.m.

Fri., Dec. 13.—MANCHESTER AND DISTRICT BRANCH : Bragg Lecture Theatre, The University, Manchester, "The Strength of Materials—with Special Reference to Metals," A. H. Cottrell, 6.45 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Dec. 9.—EAST REGIONAL CENTRE : Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, "Tyres and their Maintenance," 7.30 p.m.

Tues., Dec. 10.—MIDLANDS CENTRE : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Exhaust Brake Design and Operation," A. G. Slee, 7.30 p.m.

Wed., Dec. 11.—SOUTHERN CENTRE : Cambridge Hotel, Southsea, "The Ability to Stop," H. Clements, 7.30 p.m.

Fri., Dec. 13.—SOUTH WALES CENTRE : South Wales Institute of Engineers, Park Place, Cardiff, "The 'N' Type Injector Pump and the Hydraulic Governor," T. G. Charlesworth, 7 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Dec. 11.—MIDLANDS BRANCH : Midland Institute, Paradise Street, Birmingham, "Models for Piping Design and Construction," M. K. Brown and E. Holmes, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 10.—Great George Street, Westminster, London, S.W.1, Symposium on "Airfield Construction on Overseas Soils," 5.30 p.m.

Wed., Dec. 11.—NORTH-WESTERN ASSOCIATION : County Hall, Preston, Joint Meeting with Lancashire County Engineering Society, "Modern Road Construction," A. G. Tarrant, 6.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Dec. 6.—SOUTH MIDLAND CENTRE : Town Hall, Birmingham, "The Electrification of the British Railways," G. H. Fletcher, 6 p.m.

Mon., Dec. 9.—LONDON BRANCH : Savoy Place, London, W.C.2, Discussion on "Where Should Research End and Development Start," opened by K. J. R. Wilkinson, 5.30 p.m. ★ MALVERN AND DISTRICT GROUP : Winter Gardens, Malvern, "Luminescence as Applied to Lighting," A. H. McKeag, 7.30 p.m. ★ MERSEY AND NORTH WALES CENTRE : Royal Institute, Colquitt Street, Liverpool, "Electrical Equipment for Rectifier Locomotives," H. B. Calverley, E. A. K. Jarvis and E. Williams, 6.30 p.m. ★ NORTH-EASTERN CENTRE : Neville Hall, Newcastle upon Tyne, "D.C. Winder Drives Using Mercury-Arc Rectifier/Inverters," L. Abram, J. P. McBreen and J. Sherlock, 6.15 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE : Town Hall, Hanley, "Cathodic Protection," L. B. Hobgen, K. A. Spencer and P. W. Heselgrave, 7 p.m. ★ WESTERN CENTRE : South Wales Institute of Engineers, Cardiff, Joint Meeting with Supply and Utilization Groups, "138kV Submarine Power Cable Interconnection between the Mainland of British Columbia and Vancouver Island," T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson, 6 p.m.

Tues., Dec. 10.—LONDON GRADUATE AND STUDENT SECTION : Public Library, Chelmsford, District Meeting, "Television Film Recording," E. J. Stocks, 7 p.m. ★ NORTHERN IRELAND CENTRE : David Keir Building, Queen's University, Belfast, "Factors in the Utilization of Electrical Power in Aircraft," H. Zeffert, 6.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Informal Evening on "Electronics and Automation" and "Some Industrial Applications," H. A. Thomas, 7 p.m. ★ RUGBY SUB-CENTRE : College of Technology and Arts, Rugby, "Mechanical Strength of Power Transformers in Service," E. T. Norris, 6.30 p.m.

Wed., Dec. 11.—RADIO AND TELECOMMUNICATION SECTION : Savoy Place, London, W.C.2, "A Flying-Spot Film Scanner for Colour Television," H. E. Holman, G. C. Newton and S. F. Quinn, 5.30 p.m. ★ SHEFFIELD SUB-CENTRE : Grand Hotel, Sheffield, "Mechanical Strength of Power Transformers in Service," E. T. Norris, 6.30 p.m. ★ NORTH-WESTERN RADIO AND TELECOMMUNICATION GROUP : Engineers' Club, 17, Albert Square, Manchester, "Ferrites," D. H. Pringle, 6.45 p.m. ★ NORTH LANCASHIRE SUB-CENTRE : North-Western Electricity Board Lecture Hall, Jubilee Street, Blackburn, "The Measurement of Earth-Loop Resistance," G. F. Tagg, 7.15 p.m.

Thurs., Dec. 12.—UTILIZATION AND RADIO SECTIONS : Savoy Place, London, W.C.2, "Electrical Control of Stage and Television Lighting," F. Bentham, 5.30 p.m. ★ NORTH LANCASHIRE SUB-CENTRE : North Western Electricity Board Demonstration Theatre, Duke Street, Barrow, "The Measurement of Earth-Loop Resistance," G. F. Tagg, 7.15 p.m. ★ NORTH SCOTLAND SUB-CENTRE : Electrical Engineering, Queen's College, Dundee, "Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33kV and Above," A. Morris Thomas and D. F. Oakeshott, 7 p.m. ★ WEST WALES (SWANSEA) SUB-CENTRE : Conference Rooms, South Wales Electricity Board Showrooms, The Kingsway, Swansea, "Cathodic Protection," L. B. Hobgen, K. A. Spencer and P. W. Heselgrave, 6 p.m.

Fri., Dec. 13.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Basic Experiments on Servo Mechanisms," opened by W. Chellingsworth, 6 p.m. ★ EAST MIDLAND CENTRE : College of Technology, Leicester, Joint Meeting with Leicester Association of Engineers, "Highland Water Power—The Developments of the North of Scotland Hydro-Electric Board," by the late T. Lawrie (to be read by a member of the Board), 7.15 p.m. ★ NORTH SCOTLAND SUB-CENTRE : Robert Gordon's Technical College, Aberdeen, "Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33kV and Above," A. Morris Thomas and D. F. Oakeshott, 7.30 p.m.

Mon., Dec. 16.—RADIO AND TELECOMMUNICATION SECTION : Savoy Place, London, W.C.2, Informal Evening on "Electronics and Automation—Electronics in the Textile Industry," K. J. Butler, 5.30 p.m. ★ MERSEY AND NORTH WALES CENTRE : Town Hall, Chester, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 6.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Dec. 9.—NORTH-EAST BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "The Doxford Marine Diesel Engine," J. A. Hardy, 7.15 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., Dec. 11.—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Can Work Study be Applied to Inspection?" R. Norbury, 6.45 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Dec. 6.—LONDON BRANCH : Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "Roads from the Beginning," E. J. R. Kennerell, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 6.—INTERNAL COMBUSTION ENGINE GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Are Crankshaft Torsional Vibration Problems Things of the Past?" 6.45 p.m. ★ SCOTTISH BRANCH : North British Hotel, Edinburgh, "Vibration : A Survey of Industrial Applications," J. P. den Hartog, 6.30 p.m.

Mon., Dec. 9.—EAST MIDLANDS BRANCH : Rolls-Royce Welfare Hall, Derby, Joint Meeting with Derby A.D. Centre, "Small Gas Turbines," J. H. Weaving, 6.15 p.m.

Tues., Dec. 10.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Air or Water Cooling?" 6.45 p.m.

Wed., Dec. 11.—LUBRICATION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Reclamation of Lubricants," 6.45 p.m.

Thurs., Dec. 12.—YORKSHIRE BRANCH : Hotel Metropole, Leeds, "Atomic Energy, Steam and Power Production," W. R. Wootton, 6.30 p.m.

Fri., Dec. 13.—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "High-Pressure Hydraulic Transmission," H. Thoma, 6 p.m.

Sat., Dec. 14.—SOUTH WALES BRANCH : Visit to Guest, Keen and Nettlefolds (South Wales), Ltd., Castle Works, Cardiff, 9.30 a.m. ★ MIDLAND GRADUATES' SECTION : Morning visit to Fisher and Ludlow, Ltd., Birmingham.

INSTITUTION OF NAVAL ARCHITECTS

Mon., Dec. 9.—SOUTHERN JOINT BRANCH I.N.A. AND I.MAR.E. : College of Technology, Portsmouth, "The Use of High-Pressure Steam for Marine Installations," E. Norton, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Dec. 9.—LEEDS SECTION : Hotel Metropole, King Street, Leeds, 1, "High Cost of Low Overheads," C. H. Starr, 7 p.m.

★ SHEFFIELD SECTION : Grand Hotel, Sheffield, Joint Meeting with Institution of Welding, "High Production with Automatic Arc Welding," J. A. Lucey, 7.15 p.m. ★ LIVERPOOL SECTION : Liverpool Technical Libraries, William Brown Street, Liverpool, Libraries Lecture, The Rt. Hon. The Earl of Halsbury, 7.30 p.m.

Tues., Dec. 10.—DONCASTER SECTION : Danum Hotel, Doncaster, "The Production of Fractional Horsepower Motors," 7.15 p.m. ★ BIRMINGHAM GRADUATE SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, Film Evening, 7 p.m. ★ PETERBOROUGH SECTION : Technical College, Eastfield Road, Peterborough, "Problems in Mechanical Handling and Some Answers," W. T. Druit, 7.30 p.m. ★ OXFORD SECTION : Bicester Garrison, Oxfordshire, "Automatic Mechanical Project Factory," H. J. Graves, 7.30 p.m. ★ LONDON GRADUATE SECTION : 10, Chesterfield Street, London, W.1, "Pneumatic Gauging in Metrology," J. C. Evans, 7.15 p.m.

Wed., Dec. 11.—EDINBURGH SECTION : North British Hotel, Princes Street, Edinburgh, "Hydraulics," F. B. Levetus, 7.30 p.m.

Thurs., Dec. 12.—ROCHESTER SECTION : Assembly Room, Sun Hotel, Chatham, "The Practical Uses of Electronics in Industry," K. A. Zandstra, 7.30 p.m.

Fri., Dec. 13.—IPSWICH AND COLCHESTER SECTION : Golden Lion Hotel, Cornhill, Ipswich, "A Review of Methods for Heating and Ventilating Factories," F. Carter, 7.30 p.m. ★ DERBY SECTION : College of Art, Derby, "The 'G.F.' Copy Turning Lathe," 7 p.m. ★ SWANSEA SECTION : Central Library, Alexandra Road, Swansea, "Punched Card Development in Automation," D. Nettel, 7.30 p.m.

Mon., Dec. 16.—NEWCASTLE UPON TYNE SECTION : Neville Hall, Newcastle upon Tyne, Film Evening, 7 p.m.

INSTITUTION OF PUBLIC HEALTH ENGINEERS

Thurs., Dec. 12.—Caxton Hall, Westminster, London, W.C.2, Discussion on "Building Drainage," Opened by C. L. Langshaw, 6 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Dec. 9.—MERSEYSIDE SECTION : Exchange Hotel, Liverpool, "Earth Satellites," C. A. Cross, 7.15 p.m. ★ MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Practical Applications of Production Engineering Research," D. F. Galloway, 6.45 p.m.

Tues., Dec. 10.—LEICESTER SECTION : Bell Hotel, Leicester, "Phenolic Resins as Reinforcing Agents," S. M. Ardley, 7.30 p.m. ★ LONDON SECTION : Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, "Butyl in Mechanical Rubber Goods," M. E. Blowin, 5.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Dec. 6.—S.W. COUNTIES BRANCH : Duke of Cornwall Hotel, Plymouth, "Some Unusual Structural Engineering Problems," C. E. Saunders, 6 p.m. ★ WESTERN COUNTIES BRANCH : Engineering Laboratories, The University, Bristol, "Tubular Structures," R. G. Taylor, 6 p.m.

Tues., Dec. 10.—SCOTTISH BRANCH : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Design of Plate Girders," O. A. Kerensky, 7 p.m.

Wed., Dec. 11.—YORKSHIRE BRANCH : Central Electricity Authority, Whitehall Road, Leeds, "Post-War Developments in German Steel Bridges and Structures," G. B. Godfrey, 6.30 p.m.

Thurs., Dec. 12.—11, Upper Belgrave Street, London, S.W.1, Maclachlan Lecture, "Tandem Ferry Aprons for the Canadian Pacific Railway at Vancouver and Nanaimo, B.C., Canada," P. L. Easterbrooke, 5.55 p.m. ★ YORKSHIRE BRANCH : Royal Victoria Hotel, Sheffield, "Post-War Developments in German Steel Bridges and Structures," G. B. Godfrey, 6.30 p.m.

Mon., Dec. 16.—LANCASHIRE AND CHESHIRE BRANCH : College of Science and Technology, Manchester, "A Review of the Structural Steelwork in the 'Seraphim' Extensions at Appleby-Frodingham," S. Richards, 6.30 p.m.

INSTITUTION OF WATER ENGINEERS

To-day, Dec. 6.—WINTER GENERAL MEETING : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "The Waterworks Mechanical Engineer," J. Gardiner; "The Pitsford Treatment Works of the Mid-Northamptonshire Water Board," J. W. Milne, 10 a.m.

INSTITUTION OF WORKS MANAGERS

Tues., Dec. 10.—BIRMINGHAM BRANCH : Byng Kenrick Suite, New College, Birmingham College of Technology, Costa Green, Birmingham, "Electronics : The Way Ahead," R. B. Smith, 7 p.m. ★ SHEFFIELD BRANCH : Grand Hotel, Sheffield, "Education of Boys in Industry," D. R. O. Thomas, 7.30 p.m.

Thurs., Dec. 12.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "Some Tentative Concepts on the Subject of Management and Administration," W. Brown, 7 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Fri., Dec. 13.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Inaugural Meeting, Induction of Major-General W. A. Lord as President for 1957–58; Presentation of Awards, 1956–57, by B. Donkin, 7.30 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Dec. 12.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, Joint Meeting with Society of Chemical Industry (Liverpool Section), "Titanium," J. W. Rodgers, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Dec. 13.—Engineers' Club, Albert Square, Manchester, 2, "Chemical Engineering Education," F. Morton, 6.45 p.m.

NEWCOMEN SOCIETY

Wed., Dec. 11.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Abraham Darby (I and II) and the Coal-Iron Industry," R. A. Mott, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Wed., Dec. 11.—STUDENT SECTION : Bolbec Hall, Newcastle upon Tyne, "Some Aspects of Yacht Design," B. D. Jones, 6.45 p.m.

Fri., Dec. 13.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "The Analysis of Structures with Particular Reference to the Prediction of Deflections," T. M. Charlton, 6.15 p.m.

Mon., Dec. 16.—TEES-SIDE BRANCH : Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, Film on "M.S. 'Bergensfjord,'" 6 p.m.

PLASTICS INSTITUTE

Wed., Dec. 11.—S. WALES AND MONMOUTHSHIRE SECTION : Angel Hotel, Cardiff, "Use of Rubber and Plastics in the Cable Industry, with Particular Reference to Desirable New Materials for Telecommunication Wires and Cables," K. H. Whitlock, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

To-day, Dec. 6.—12, Great George Street, London, S.W.1, "The Coal Mining (Subsidence) Act, 1957," E. Rutherford Young, 5.45 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Dec. 10.—B.I.S.R.A., Hoyle Street, Sheffield, "Some Everyday Refractory Problems," P. W. Clark, 7 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Dec. 12.—Institute Buildings, Park Place, Cardiff, "The Development of Hydrox for Underground Loading," I. O. Lewis and R. Watt, 6 p.m.